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CONTENTS.

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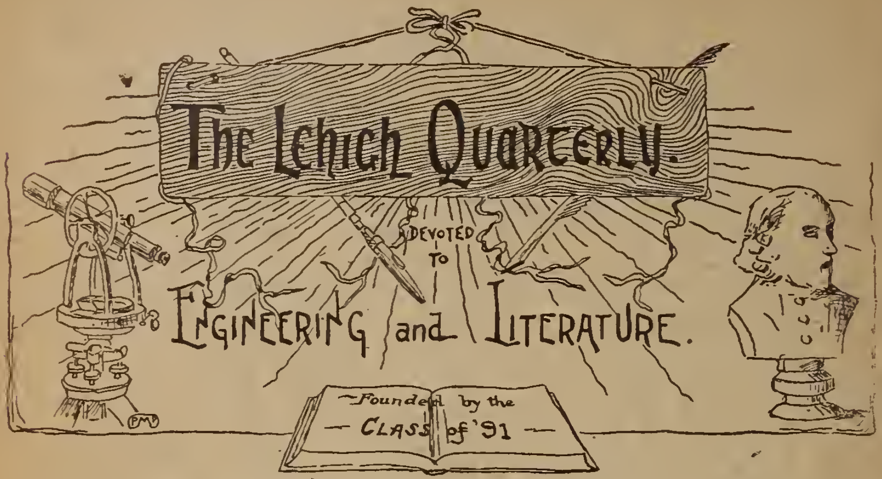

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THE

LEHIGH QUARTERLY.

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Vol. III. JUNE, 1893. No. 3.

THE BIOLOGICAL THEORY OF DISEASE.

As long as medicine (used in the generic sense) depended upon deductive methods for its advancement, it was of a necessity a purely empirical art. All the modern researches which have proven of any value in medicine have been inductive, and medicine today begins to assume the proper position among the other natural sciences through methods as exact and synthetical as those of chemistry or botany. While not yet established fairly as an exact science, medicine is so far advanced towards that goal, that a few more years will probably suffice to set it in its proper niche.

The humoral theory of Galen, and solidist theory of Hoffman and Cullen occupied rival positions as explanations of disease for many acrimonious years. The battles waged pro and con, but nothing tangible was reached. The old schoolmen's methods of disputations simply led in a circle, and until the middle of the present century no abiding light, nor any tangible collection of facts, sufficed to produce a scientific concept of disease as to its causes.

The first glimmer of the modern theory was obtained through the classical experiments of Tyndal — the discovery of floating particles in the air by filtering the air, and thus depriving a sunbeam of light. Then the proof that putrefaction could be

delayed almost indefinitely by excluding the air, or by thorough filtering of the air. Pasteur carried the light a little further by his discovery that alcoholic fermentations are due to the agency of a certain plant — the yeast plant: also by his discovery of the bacillus of chicken cholera.

Lister founded on these discoveries, and certain others made by himself with reference to putrefactive changes, the synthesis of Antisepticism in Surgery. This theory was that as the air contained and carried the elements of putrefaction, and as all suppuration is a form of putrefaction, exclude the air, or disinfect the air and surroundings of wounds, then these changes would not occur. His results were so brilliant that the world immediately took up the idea and practice.

The German schools soon outstripped Lister and his followers. The original experiments of Tyndal were recalled, and as absolute exclusion of atmospheric air was, practically, impossible, they originated the filtering methods of surgical dressings. Starting with the surgeons this "Germ Theory" as it is called, threw such brilliant side lights upon all so-called specific infectious diseases, that numerous investigators began in the laboratory experiments and researches to discover and isolate the specific organisms which they thought must bring about specific diseases. A long list of discoverers soon published startling and most useful results. Koch isolated the bacillus of tuberculosis, and the bacillus of cholera; Klebs and Loefler the bacillus of diphtheria; Ebers the bacillus of typhoid fever; Friedlander the diplococcus of pneumonia. Several observers about the same time confirmed Ebers' specific bacillus in typhoid fever, and so on. These positive determinations have revolutionized the former pathological theories. No one, now, speaks of certain *humors* being so modified that diseases result, nor that the *solid tissues* becoming disorganized, certain diseased conditions are brought about. It is now, such and such a bacillus has invaded an individual and the result is a specific diseased condition.

Biologists are not yet agreed as to the classification of bacteria. That they are plants is conceded by all of the best observers; but whether they are algæ or fungi, or whether some belong to one class and others to the other, is still a moot question. The

classification into genera and species is also not yet settled. The morphological classification is perhaps most commonly followed. According to this method two primary classes may be made: 1. Globular forms or "monads;" and 2. Filiform or "bacterium" proper. Isolation or grouping produce every conceivable variety from the two primary states.

Bacteria vary very much in size. Some are so small as scarcely to be perceived by the highest powers of the best microscopes, while others reach a size of 2-10 millimeter. The globular are the smallest—to this class belong the *micrococci.* The filiform are the largest. To this class belong the "bacilli," the "spirillæ," etc. Two kinds of movements distinguish bacteria: (*a*) Molecular, or motion of the corpuscle on itself, and (*b*) Translation, by cilia.

There are three theories as to the origin of the bacteria: (*a*) The heterogeneous or spontaneous generation. (*b*) Fission, that is that they develop from organisms like themselves by endogenous division. (*c*) Evolution, that is that they are developed from organisms of a lower order.

Tyndall and Pasteur have conclusively disproved the first theory.

The second theory, while admittedly true as a law with reference to the multiplication of the species, has not been proven, and is difficult of conception as an *origin* of species. While hundreds of observers have repeatedly noticed that their culture liquids have swarmed with an hundredfold increase, if a careful exclusion of any possibility of foreign admixture has been made, no one has been able to demonstrate a single change in the genus. It is as true of bacteria as of every other class of organisms that "like produces like," *the conditions remaining the same.* Change the environment, cultivate a species under different conditions from that in which it was found, and it will change. This is in keeping with the whole order of natural growth. This, however, is the *third* theory, and it is, doubtless, the correct one.

Bacteria multiply by (*a*) fission, (*b*) spores, and (*c*) by sporangia, even. The spore is the most active condition of bacteria, and in this state they are chiefly disseminated.

The physiology of bacteria is very simple. They require warmth, moisture, sunlight, nitrogen, carbon, and oxygen. A temperature of 212° F. kills all bacteria if prolonged. Spores

have been known to resist boiling for quite a time, however. A temperature of 176° F. arrests their growth, but does not kill. Cold has much less effect than heat. Freezing serves only to arrest their activity. A restoration of warmth brings about renewed activity and rapid growth. Bacteria are found actively present in all vegetable and animal fermentation and putrefaction. Their specific *rôle* in these processes is, however, not yet determined. Bacteria are found in the air, earth, and water. We breathe them, we drink them, and we eat them. As they are so omnipresent one would seem to be in constant danger of infection and disease. The study of the life history of micro-organisms and laboratory researches, have demonstrated beyond a doubt that while probably every acute disease is due to an invasion of a certain specific organism, there are certain contra-forces at work within every animal organism which resist and nullify the evil effect of hurtful bacteria, and it is only when the proper resistance of living tissue is diminished or disorganized that injurious lodgment of these little plants can take place.

There are two factors in infection, therefore. First, the specific microbe must have found a lodgment in the system, and, secondly, the normal animal cells (white corpuscles, lymph cells, serum, and perhaps connective tissue cells) must be overcome by (*a*) some lessened resistance on their part, such as by previous disease or by lack of proper food and air; (*b*) by an overpowering virulence of invasion—that is, a lodgment of so many of the infectious micro-organisms in their most active state (spores) that the resistance of the cells is overcome.

This explains why, as a rule, an epidemic is characterized by a tide-like rise, flood, and ebb. In the beginning the condition of the people is normal, and the micro-organisms are present in numbers only sufficient to overcome a few persons, and in localities favoring their development, where filth and crowding abounds; later the stress of nursing and care for the sick, and the accumulation of the microbes, the one reduces the stamina of the community, the other increases the invading forces, so to speak. Victims therefore multiply. These micro-organisms are short lived. If by help from outside, and a general awakening to the necessity of isolation, the locality is made clean, and the

infected people and houses be effectually quarantined, the unaffected persons are able to take care of their health, and the microbes die out for lack of proper media in which to further multiply. The question of *carrying* infection is now pretty well understood. Each of the specific diseases has a special predilection for a certain organ or tract of the body. For instance, diphtheria selects chiefly the upper air passages and fauces (nose and throat), typhoid fever the small intestines, dysentery the large intestines, tuberculosis the lungs, the eruptive fevers the skin, and so on. While the microbes are soon pretty well distributed over the whole body by the circulation, their number is comparatively small and they are far less virulent than at the places of election—usually where the disease first makes a characteristic manifestation of itself. Any secretion or excretion from these affected areas contain millions of micrococci or bacilli. These excretions are ejected, and are apt to soil the clothing of attendants, the bedding, walls and carpet of the room. In a short time they become dry, and may be taken up by the air and carried outside and infect the surroundings. Or the excretions may be deposited in drains and sewer pipes, and so be carried to some common water supply. Some microbes multiply in the air, others thrive in water. Unless dessicated by a high degree of heat the ærobic microbes may preserve life and activity for a long period, the anærobic which are deposited in water may live indefinitely. Freezing will not kill them. Hence the propagation of typhoid fever by infected ice supplies, and the infection of water courses by melting snows.

Infective micro-organisms may be carried and disseminated, then, by the air, in water, by clothing and fabrics belonging to the furnishing of a house, by the soiled skin, hair, and *nails* of attendants, by domestic animals, and, in a few instances, by the soil.

However obtained, the two conditions for their development must be present in order that disease shall result—viz., (1) they must be received in an active state, and (2) they must find a favorable condition in the host for their development.

Very interesting phenomena take place when a lodgment is effected anywhere in the system. There are certain cells in the

body the type of which are white blood corpuscles and large lymphoid cells, which are amœboid in motion and function. These are the protectors and scavengers of the animal system. As soon as infection takes place, the point is immediately surrounded by multitudes of these cells, and they immediately set about enveloping the invading micro-organisms or foreign substance: each cell appropriates as many as it can encompass in itself, just as an amœba gradually takes in infusoria, by pushing itself against them and gradually surrounding, and finally taking them within the cell. Once within the cell they are digested and destroyed. This process is called "phagocytosis," an eating up of the micro-organism by the amœboid cells. It is now known that all living animal cells have this quality, but inasmuch as the white blood corpuscles and lymph cells are migratory they act as the standing army for the system, and are ready and prompt to meet an invading enemy at whatever confine or boundary he may make his appearance, and, cannibals as they are, proceed at once to devour the invaders.

If, however, through stress of numbers the invading hosts of micrococci or bacilli are too many for the cells, or if through stress of ill health, caused by poor food, poor air, etc., or previous illness, the power and number of the cells be diminished, the micro-organisms begin to multiply at the expense of the cells, the cells are killed and disintegrated, and the micro-organisms feed on *them*. Just as in saccharine fermentations certain bye-products are produced, so in the tissue disintegrations certain nitrogenous products are produced. These products are called ptomaines, leucomaines, tox-albumins, etc. They become soluble, are taken up by the blood current, and are carried throughout the system. They are usually active poisons, having some of them a similarity in chemical reaction and toxic effect very much like some of the well-known alkaloids. It is these nitrogenous poisons, produced by the action of the micro-organism, that produce the diseased conditions, not the micro-organisms themselves.

The continuance of the disease and severity of the attack depend entirely upon the power of the protecting cells, and the condition of the host as to furnishing a favorable medium for multiplication. Individual micro-organisms are short lived, the

disease must cease as soon as the further development of the plants is prevented. If therefore the system is not so saturated with the poisonous tox-albumins that cell activity may again reach a status sufficient to overcome the invading organisms, as soon as the first "crop" of the invaders is finished, the cells again obtain the ascendency, and the illness ceases by a gradual elimination of the poisons through the normal channels of excretion.

Modern treatment of disease therefore should aim at thorough disinfection (which means the employment of measures to kill or prevent the development of the bacteria) at the very beginning of a disease, at the point of lodgment or selection, and thus attempt to counteract and hasten the elimination of the nitrogenous poisons. If it is impossible as it commonly is, to reach the point of election in time, or at all, the chief factor in the management of disease is to so nourish and nurse the patient that the tissues shall regain their tone, and preserve the activity of the cells until the micro-organisms shall find no further appropriable food, and so cease multiplying; then the cells will begin their work of extermination and soon free the system of the infection.

The rationale of protective vaccinations and inoculations is explained by the fact of the modifications the tox-albumins undergo in one passage through an animal body, or through a culture liquid. The specific bacteria remain the same, they are but attenuated by the spore becoming developed into a full grown mycelium or coccus, in which state it is much less active in growth, and the production of tissue disorganization. The chief difference is, however, in the constitution of the poisonous alkaloid or albumin. This by culture is chemically re-arranged, so that while it may possess similar elements, the graphic formula is quite different, and in this state it may enter the system and produce only a mild degree of "reaction." Another point which has not yet been emphasized is that since, in vaccinating and inoculating, the specific "virus" is usually introduced into the system in an entirely different manner and avenue from its course of election—that is when the disease is acquired after the usual manner—it is not able to propagate as rapidly and vigorously as when it enters and seeks its own locale: the result is an easy victory for the amoeboid cells.

The question of immunity is difficult to answer at the present stage of investigation. It is believed that just as certain soils will retain, nourish and cause to grow seeds which another soil will totally reject, so certain human beings exhibit wonderful powers of resistance against specific diseases because they do not furnish suitable media for the development of the micro-organisms. It is also supposed that the value of protective inoculation is the bringing about this condition of intolerance for specific germs through a chemical sterilization which the inoculation obtains in the cells and fluids of the body. W. L. ESTES.

CATALOGUE OF ARTICLES IN THE EXHIBIT OF THE LEHIGH UNIVERSITY AT THE WORLD'S COLUMBIAN EXPOSITION, 1893.

PREPARED BY MANSFIELD MERRIMAN, CHAIRMAN OF THE FACULTY'S COMMITTEE ON EXHIBIT.

PHOTOGRAPHS.

1. Asa Packer, Founder of The Lehigh University.
2. Packer Hall and the Library: South-west view, and two south-east views.
3. Packer Memorial Church, exterior and interior. Gymnasium, exterior and interior.
4. Library: Two interior views, doorway, and rear view.
5. Christmas Hall, Saucon Hall, the University Park, and Athletic Grounds.
6. New Physical Laboratory: Elevation, longitudinal section, and floor plans.
7. New Physical Laboratory: Cross-section and floor plans, front view from architect's sketch, and rear view taken March 20, 1893.
8. Physical Laboratories in Saucon and Christmas Halls: Lecture room, dynamo room, mechanics and heat, magnetism and electricity.
9. The Sayre Observatory: Exterior and two interior views. Physical apparatus made by students.
10. Hydraulic Laboratory: Cement room, and turbine and hydraulic ram. Packer Hall: Mechanical engineering drawing room, and mechanical engineering Senior drawing room.
11. The President and Professors, 1893.
12. Chemical and Metallurgical Laboratory: Floor plans.
13. Chemical Laboratory Fixtures.
14. Chemical Laboratory: Sectional plans and chemical museum.
15. Packer Hall: Civil engineering drawing room, civil engineering lecture room and surveying instruments, civil engineering Senior drawing room, and Museum of Geology and Ornithology.

16. Mineralogical Museum, Mineralogical Laboratory, Blowpipe Analysis Room, and Metallurgical Laboratory.
17. Chemical and Metallurgical Laboratory: Front view, angle view, rear view, and still for water.
18. Chemical Laboratory: Quantitative and qualitative rooms.
19. Chemical Laboratory: Lecture room, laboratory for organic chemistry, assaying laboratory, laboratory for industrial chemistry.
20. Chemical Laboratory: Gas works, sugar refinery, calico printing machine, acohol still.

STATISTICS, CHARTS, AND MAPS.

31. List of Alumni of the Lehigh University, 1869–1892.
32. List of officers and students for the collegiate year 1892–93.
33. Comparison of rosters of recitations, 1870 and 1893 (106 recitations per week in 1870, and 356 in 1893).
35. Map of Bethlehem, South Bethlehem, and West Bethlehem, showing location of the University with respect to industrial establishments. Prepared by R. M. Wilcox, Instructor in Civil Engineering.
36. Comparison of Classes, '69 to '96 inclusive, showing the number of Freshmen, Sophomores, Juniors, Seniors, and Graduates in each. Prepared by John S. Siebert, Instructor in Civil Engineering.
37. Map of portions of New York, New Jersey, and Pennsylvania, showing places and objects visited by students in tours of inspection. Prepared by Edward H. Williams, Jr., Professor of Mining Engineering and Geology.
38. Topographical Map of Lehigh University Park, showing dates of erection of buildings. Prepared by John P. Brooks, Instructor in Civil Engineering.
39. Chart showing the growth of numbers of students, 1866 to 1893. Prepared by John S. Siebert, Instructor in Civil Engineering.
40. Programs of Study in the School of General Literature, comprising the Classical Course, Latin Scientific Course, and Course in Science and Letters.

41. Chart showing the numbers of students in the different courses during eleven years, 1882 to 1892. Prepared by John P. Brooks, Instructor in Civil Engineering.
42. Programs of study in the School of Technology, comprising the Courses in Civil Engineering, Mechanical Engineering, Mining Engineering, Physics and Electrical Engineering, Analytical Chemistry, and Architecture.

EXAMINATION QUESTIONS.

45. Scrap Book containing copies of the questions given in the entrance examinations and in the examinations of classes during the year 1892.

46–48. Examination questions of the second term, January to June, 1893, with the best two answers by students in each subject.

PUBLICATIONS OF THE UNIVERSITY.

52. Register of the Lehigh University, 1868–1875. One volume, 8vo.
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152. Description of Illustrative Apparatus for the Teaching of Ancient Languages and History.

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176. Design of Planing Attachment for 12-inch Lathe. By R. Paul Stout, 1891.
167. Efficiency of a One-ton Triplex Spur Gear Block. By Alfred E. Lister, 1892.
168. Plans for and Estimate of Cost of Fitting up a Forty-Barrel Flouring Mill. By C. O. Wood, 1892.

ELECTRICAL ENGINEERING: GRADUATING THESES OF STUDENTS.

173. A Series of Tests of a Thomson-Houston Dynamo. By P. D. Honeyman, 1891.

174. An Investigation of the Westinghouse Alternating Incandescent System. By G. E. Wendle, 1891.
175. An Experimental Study of the Working Conditions of the Electric Railway Motor. By W. W. Blunt, 1892.
176. Loss of Energy in the Transformer by Hysteresis. By J. T. Loomis, 1892.
177. The Opened Magnetic Circuit Transformer; a general discussion, and also a test of a 10-light Transformer. By S. A. Rhodes, 1892.
178. A Test of the Cars of the Savannah Street Railroad Company, with a view to determining the power absorbed by different styles of motors. By M. N. Usina, 1892.

EXHIBITS BY THE STUDENTS.

181. *Journal of the Engineering Society* of The Lehigh University. Vols. I–V, 1885–1890. One volume, 8vo.

182–184. *The Lehigh Quarterly*, Vol. I, 1891, Vol. II, 1892, Vol. III, No. 1, February, 1893.

185. *The Epitome*, published by the Class of '92. 4to, pp. 274.

187. *Students' Hand Book.* Number One. Published by the Lehigh University Christian Association. 18mo., pp. 44.

188. *Students' Hand Book.* Number Two. Published by the Lehigh University Christian Association, 18mo., pp. 48.

189. *The Lehigh Burr*, published every ten days by students of The Lehigh University. Vol. XI, 1891–1892. 4to.

190. An Aid of the Game of Lacrosse. By J. R. Flannery, A. K. Reese, S. M. Cone, T. H. Symington. Published by the Lacrosse Association, 1891. 12mo., pp. 24.

191. Intercollegiate Championship Lacrosse Banner. Won by Lehigh University Lacrosse Team, 1890.

192. Three Interior Views of Packer Memorial Church. Photographed by William P. Marr, Class of '93.

193. Photograph of the Senior Class, April, 1893.

194. Photograph of Lacrosse Team, 1892.

195. Photograph of Base-Ball Nine, 1892.

196. Photograph of Foot-Ball Team, 1892.

197. Photograph of Musical Organizations starting on a trip, February 17, 1893.
198. Photograph of the Banjo Club, 1893.
199. Photograph of the Orchestra, 1893.
200. Photograph of the Glee Club, 1893.

CIVIL ENGINEERING: FRAMED DRAWINGS OF STUDENTS.

201. Design of a Lattice Girder Bridge. Senior year, second term. By F. C. Warman, February, 1893.
202. Colored Map of Railroad Survey. Junior year, second term. By Chas. D. Marshall, May, 1887.
203. Design of a Pratt Truss Pin-Connected Bridge. Senior year, second term. By C. L. McKenzie, March, 1893.
204. Twenty Plates in Freehand Drawing and Lettering. Freshman year, first term. By F. Bayard and D. W. Wilson, Nov.–Dec., 1892.
205. Colored Topographical Map. Sophomore year, second term. By G. E. Greene, March, 1888.
206. Blue Print of Topographical Map of Lehigh University Park. Junior year, first term. By class of '92, Sept.–Oct., 1890.
207. Graphical Analysis of a Crescent Roof Truss. Junior year, second term. (M.E. and E.M. Courses, Senior year, first term). By H. B. Evans, December, 1892.
208. Graphical Analysis of a Plate Girder. Junior year, second term. By. W. F. Cressman, June, 1892.
209. Results of Test of the Turbine in the Civil Engineering Laboratory. Senior year, second term. By J. B. Glover, May 18, 1888.
210. Graphical Analysis of a Triangular Truss. Junior year, second term. By C. S. Haines, May 5, 1892.
211. Elevations of a Frame Cottage. Sophomore year, first term. By F. A. Wicks, Oct., 1887.
212. Plan of Electric Light Station in Bethlehem. Sophomore year, first term (Electrical Course). By J. L. Neufeld, November, 1891.

213. Plans of a Double Brick House. Sophomore year, first term. By W. P. Cody, November, 1892.

215. Foundation and Framing Plans of a Cottage. Sophomore year, first term. By L. D. Showalter, October, 1892.

216. Floor Plans of a Cottage. Sophomore year, first term. By R. R. Hillman, December, 1889.

217. Cylindrical Arch intersected by a Plane and Semi-Cylinder. Junior year, second term. By W. M. Hall, March, 1893.

218. Design of a Plate Girder Bridge. Senior year, first term. By G. H. Maurice, November, 1892.

219. Comparison of the Programmes in the Civil Engineering Course, 1870, 1880, 1890.

220. Arch Culvert and Wing Wall. Junior year, second term. By J. D. Ferguson, March, 1879.

221. Colored Topographical Signs. Sophomore year, second term. By B. Hipkins, February, 1892.

222. Colored Topographical Map. Sophomore year, second term. By L. Rights, May, 1891.

223. Contour and Profile Exercise. Sophomore year, second term. By R. Ferriday, March, 1891.

224. Title Page for Plates in Topographical Drawing. Sophomore year, second term. By H. F. Nase, April, 1893.

225. Topographical Signs. Sophomore year, second term. By P. S. Rios, April, 1892.

226. Conventional Tints. Sophomore year, second term. By L. S. Duling, Feb., 1893.

227. Title Page for Plates in Descriptive Geometry and Freshman Drawing. Freshman year, second term. By J. C. Sesser, March, 1893.

228. Tracing of Gothic Windows. Freshman year, second term. By H. J. Downs, March, 1893.

229. Queen Post Truss Bridge. Freshman year, second term. By C. L. Olmstead, April, 1890.

230. Plan, Elevation, and Isometric of a Pillow Block. Freshman year, second term. By W. B. Keim, May, 1892.

231. Elementary Projections. Freshman year, second term. By E. M. Durham, Jr., February, 1893.
232. Eight Freehand Sketches and Surveying Exercises. Freshman year, second term. 1893.
233. Line Shade Drawing of a Railroad Bridge. By E. B. Wiseman, March, 1888.
234. Topographical Map. Junior year, first term. By J. L. Burley, December, 1892.
235. Skew Arch at Reading, Pa. Junior year, second term. By J. H. Budd, April, 1892.
236. Twenty Freehand Sketches. Freshman year, first term. 1892.
238. Plan of Land in South Bethlehem. Sophomore year, first term. By H. F. Nase, October, 1892.
239. Graduated Tints. Sophomore year, second term. By W. P. Massey, 1889.
240. Conventional Signs. Sophomore year, second term. By W. A. Payne, March, 1892.
241. Plan and Elevation of a Cottage. Sophomore year, first term. By W. B. Keim, October, 1892.
242. Isometric Details of Cottage. Sophomore year, first term. By W. Forstall, September, 1888.
244. Investigation of a Retaining Wall. Junior year, second term. By G. E. Gay, March, 1889.
276. Plans and Elevation of the Crane Memorial Library. Junior year, first term (Architectural Course). By W. A. Payne, December, 1892.
277. Shades and Shadows on a Tuscan Column. Junior year, first term (Architectural Course). By H. Schneider, October, 1892.

CIVIL ENGINEERING: SETS OF DRAWINGS, NOTE BOOKS AND GRADUATING THESES OF STUDENTS.

247. Bound Set of Twenty-Seven Plates in Freehand Drawings. Freshman year, first term. By J. A. McClurg, 1887.
248. Bound Set of Twenty-Six Plates in Freehand Drawing. Freshman year, first term. By J. P. Culbertson, Jr., 1889.
249. Bound Set of Plates in Freehand Drawing and Lettering. Freshman year, first term. By S. E. Beeler, 1892.

250. Surveying Problems. Freshman year, first term. 1889–91.

251. Freehand Plotting and Surveying Exercises. Freshman year, second term. 1893.

252. Set of Twenty-three Plates in Descriptive Geometry and Projection Drawing. Freshman year, second term. By T. W. Wilson, 1891.

253. Set of Twenty-three Plates in Projection Drawing and Descriptive Geometry. Freshman year, second term. By C. L. Olmstead. 1890.

255. Set of Nine Plates in Architectural and Topographic Drawing. Sophomore year, C.E. Course. 1890.

256. Set of Three Plates in Architecture. Sophomore year, first term. Electrical Engineering Course. 1892.

257. Reports of Field Work in Surveying. Sophomore year. 1887–90.

258. Transit and Level Book. Sophomore and Junior years. A. Cardenas, 1887–89.

259. Transit and Level Book. Sophomore and Junior years. By G. Nauman, 1887–89.

260. Transit and Level Book. Sophomore and Junior years. By W. C. Perkins. 1887–89.

266. Reports of Field Work in Topographic Surveying. Junior year, first term. 1889–92.

267. Reports of Tests of Hydraulic Cements and Mortars. Junior year, first term. 1891–92.

268. Reports on Testing Machines and on the Strength of Materials. Junior year, first term. 1890–92.

269. Lectures on Construction, by Mansfield Merriman, Professor of Civil Engineering. Junior year, first term. Notes taken by T. W. Wilson, 1892.

270. Set of Eleven Sheets of Recitation Work in Stereotomy. Junior year, second term. 1893.

271. Set of Location Maps, Profiles, Cross Sections, and Estimates for a Line of Railroad. Junior year, second term. 1889–93.

272. Field Notes of Topographic and Railroad Surveying. Sophomore and Junior Years. By T. C. J. Baily, Jr., 1887–89.

273. Transit and Level Book. Sophomore, Junior, and Senior years. By Geo. H. Maurice, 1890–92.

274. Transit and Level Book. Sophomore, Junior, and Senior years. By C. S. Haynes, 1890–92.

275. Twelve Cement Briquettes made and Tested by Junior Civil Engineers. Junior year, first term. 1891–92.

280. Reports of Field Work in Geodetic Surveying. Senior year, first term. 1888–92.

281. Lectures on Bridges, by Mansfield Merriman, Professor of Civil Engineering. Senior year, first term. Notes taken by F. E. Bray, 1892.

282. Reports on Tests of the Eureka Turbine in the Civil Engineering Laboratory. Senior year, second term. 1889–91.

283. Computation Book in Bridge Design. Senior year. By Eric Doolittle, 1890–91.

284. Computation Book in Bridge Design. Senior year. By G. H. Maurice, 1892–93.

285. Review of Japanese Railways, based upon Wellington's Economic Theory of Railway Location. Graduating Thesis, by S. Yamaguchi, 1888.

286. Design for a High Trestle. Graduating Thesis, by L. P. Gaston, 1889.

287. Design of an Iron Highway Cantilever Bridge and Viaduct across the Lehigh River at Bethlehem, Pa. Graduating Thesis by T. C. J. Baily, jr., and F. E. Fisher, 1890.

288. The Geographical Location of the Salem Lutheran Church. Graduating Thesis by J. E. Boatrite, 1891.

289. The Utilization of the Water Power of the Lehigh River. Graduating Thesis by P. L. Cobb, 1892.

290. Railroad Rail Joints. Graduating Thesis, by N. W. Smith, 1893.

292. Lectures on Water Supply by Mansfield Merriman, Professor of Civil Engineering. Notes taken by F. C. Warman, 1893.

299. Statement of Drawing done by Students in the various Class, Field, and Office Exercise of the Department of Civil Engineering.

CHEMISTRY: DYES AND CHEMICALS MADE BY STUDENTS.

301. Fifty-four Bottles of Organic Preparations. By Junior Chemists.
302. Four Specimens of Calico Prints. By Senior Chemists, 1892.
303. Eighteen Specimens of Dyed Woolens. By Senior Chemists, 1892.
304. Sixteen Specimens of Dyed Cotton. By Senior Chemists, 1892.
305. Twelve Specimens of Dyed Leathers. By Senior Chemists, 1892.
306. Nine Specimens of Dyed Paper. By Senior Chemists, 1892.
307. Thirty-two Specimens of Dyed Cotton Yarns. By Senior Chemists, 1892.
308. Thirty-nine Specimens of Dyed Silk. By Senior Chemists, 1892.
309. Twenty-six Specimens of Dyed Woolen Yarns. By Senior Chemists, 1892.
310. Thirty Bottles of Chemically Pure Salts. By Senior Chemists.

CHEMISTRY: PHOTOGRAPHS, NOTE BOOKS, AND GRADUATING THESES OF STUDENTS.

311. Album of Photographs. By Senior Chemists.
312. Lecture Notes, Inorganic Chemistry. Freshman year. By H. H. Beck, 1892.
313. Lecture Notes, Inorganic Chemistry. Freshman year. By M. J. Bucher, 1892.
314. Lecture Notes, Inorganic Chemistry. Freshman year. By T. S. Eden, 1892.
315. Lecture Notes, Inorganic Chemistry. Freshman year. By H. E. Wheeler, 1892.
316. Lecture Notes, Organic Chemistry. Junior year. By W. C. Carnell, 1892.

317. Lecture Notes, Organic Chemistry. Junior year. By M. B. Graff, 1892.
318. Lecture Notes, Practical Chemistry, Notes of Practical Work. Senior year. By W. S. Maharg, 1892.
319. Lecture Notes, Industrial Chemistry, Notes of Practical Work. Senior year. By S. C. Potts, 1891.
320. Lecture Notes, Industrial Chemistry, Notes of Practical Work. Senior year. By R. B. Randolph, 1892.
321. Thesis: Some investigations on the Coefficient of Expansion of Solutions. By J. E. Bucher, 1891.
322. Thesis: The Mears Chlorination Process. By W. S. Cramp, 1881.
323. Thesis: History of the Theory of Chemistry. By H. E. Kiefer, 1892.
324. Thesis: Analysis of a Meteorite. By H. L. McIlvaine, 1888.
325. Thesis: Aluminium. By J. W. Richards, 1886.
326. Thesis: Preparation of Artificial Indigo. By G. M. Richardson, 1886.

METALLURGY: FRAMED DRAWINGS OF STUDENTS.

401. Exercise in Tinting. Freshman year, second term. By W. G. Whildin, April, 1892.
402. Exercise in Tinting. Freshman year, second term. By W. H. Brown, April, 1892.
403. Exercise in Manipulation of Instruments. Freshman year, second term. By D. F. McKee, January, 1893.
404. Pencilled Machine Sketches. Freshman year, second term. By H. Eckfeldt and W. G. Whildin, February, 1892.
405. Drawing of a Globe Valve. Freshman year, second term. By W. G. Whildin, February, 1892.
406. Drawing of Eccentric and Strap. Freshman year, second term. By H. Eckfeldt, March, 1892.
407. Drawing a Gate Valve. Freshman year, second team. By H. Eckfeldt, February, 1892.
408. Pencilled Isometric Sketches. Freshman year, second term. By H. Eckfeldt and J. G. Mason, March, 1892, and March, 1893.

409. Isometric Drawing of a Vise. Freshman year, second term. By B. H. Jones, March, 1891.
410. Isometric Drawing of an Axle Box. Freshman year, second term. By J. G. Mason, March, 1893.
411. Problems in Descriptive Geometry. Freshman year, second term. By J. G. Mason, March, 1893.
412. Intersections of Eye Bolt, Stub End, and Steam Cock. Freshman year, second term. By E. C. Thurston, March, 1893.
413. Title Page. Freshman year, second term. By H. Eckfeldt, May, 1892.
414. Intersection of Boiler and Dome. Freshman year, second term. By W. G. Whildin, March, 1892.
415. Intersection of Inclined Pipes. Freshman year, second term. By J. G. Mason, March, 1893.
416. Intersection of Hood and Branch Pipe. Freshman year, second term. By J. G. Mason, March, 1893.
417. Line Shading. Freshman year, second term. By H. Eckfeldt, April, 1892.
418. Mining Problems. Freshman year, second team. By W. G. Whildin, April, 1892.
419. Mining Problems. Freshman year, second term. By W. G. Whildin, May, 1892.
420. Mining Problems. Freshman year, second term. By W. G. Whildin, May, 1892.
421. Drawing of Bell and Hopper Details. Freshman year, second term. By W. V..Pettitt, May, 1892.
422. Drawing of Mine Car Details. Freshman year, second term. By C. H. Thompson, April, 1891.
423. Drawing of Band Brake. Freshman year, second term. By B. H. Jones, March, 1891.
424. Drawing of Blast Furnace Charging Apparatus. Freshman year, second term. By H. Eckfeldt, May 1892.
425. Problems in Machine Design. Freshman year, second term. By W. G. Whildin, May, 1892.
426. Drawing of a Blast Furnace. Sophomore year, first term. By B. H. Jones, December, 1891.

427. Drawing of a Blast Furnace. Sophomore year, first term. By H. Eckfeldt, November, 1892.
428. Drawing of a Blast Furnace Charging Apparatus. Sophomore year, first term. By J. T. Callaghan, November, 1892.
429. Plan of the Blast Furnaces of the Bethlehem Iron Co. Sophomore year, first term. By B. I. Drake, November, 1892.
430. Drawing of the Hangers and Supports used about a Blast Furnace. Sophomore year, first term. By F. Baker, November, 1892.
431. Drawing of a Tuyere and its connections. Sophomore year, first term. By H. Eckfeldt, November, 1892.
435. Design of a Blast Furnace Charging Aapparatus. Senior year, first term. By H. Orth, February, 1893.
436. Design of a Blast Furnace Charging Apparatus. Senior year, first term. By H. Orth, February, 1893.
438. Design of a Blast Furnace Charging Apparatus. Senior year, first term. By N. Banks, February, 1893.
439. Design of a Blast Furnace Charging Apparatus. Senior year, first term. By N. Banks, February, 1893.
442. Design of Hot Blast Stove. Senior Class, second term. By H. Orth, April, 1893.
445. Description of Metallurgical Drawings.

METALLURGY: NOTE-BOOKS, REPORTS, AND GRADUATING THESES OF STUDENTS.

432. Shop Visits and Reports. Sophomore Class, first term. By the Class, December, 1891.
433. Shop Visits and Reports. Sophomore Class, first term. By H. Eckfeldt, December, 1892.
434. Shop Visits and Reports. Sophomore Class, first term. By F. S. Young, December, 1892.
437. Memoir Accompanying the Design of a Blast Furnace Charging Apparatus. Senior year, first term. By H. Orth, February, 1893.
440. Memoir Accompanying the Design of a Blast Furnace Charging Apparatus. Senior Class, first term. By N. Banks, February, 1893.

441. Memoir Accompanying the Design of a Blast Furnace Charging Apparatus. Senior Class, first term. By J. S. B. Hollinshead, June, 1891.

443. Memoir Accompanying the Design of a Hot Blast Stove. Senior Class, second term. By H. Orth, April, 1893.

444. Memoir upon the Design of a Hot Blast Stove. Senior Class, second term. By N. Banks, May, 1893.

446. Thesis: A Description of the Plant of the Lehigh Zinc & Iron Co., Limited, for the Manufacture of Spiegeleisen, South Bethlehem, Pa., including a Determination of the Distribution of the Manganese. Post-Senior year, second term. By J. A. Jardine, June, 1885.

447. Thesis: Heat Requirement of an Anthracite Blast Furnace. Post-Senior year, second term. By F. F. Amsden, June, 1888.

448. Thesis: Heat Distribution and Description of the Spiegel Furnace of the Lehigh Zinc & Iron Co. Post-Senior year, second term. By F. L. Grammer, June, 1890.

449. Thesis: Description of the Bessemer Process as Employed at the Bethlehem Iron Co. Senior year, second term. By Jos. Barrell, June, 1892.

450. Thesis: A Comparison of Some Regenerative Hot Blast Stoves. Senior year, second term. By R. E. Ozias, June, 1892.

451. Thesis: On the Method Employed in the Erection of a Ten Stamp Gold Mill as Used in the Darien Gold District, Republic of Columbia. Senior year, second term. By H. F. Lefevre, June, 1892.

REGISTER.

501. Registry Book in which all officers, alumni, and students, now or formerly connected with the University, are requested to record their names and addresses.

BIBLIOGRAPHY.

502. A List of Publications by professors, instructors, and students now or formerly connected with The Lehigh University. Prepared by B. W. Frazier, Secretary of the Faculty's Committee on Exhibit.

LOCATION AND ARRANGEMENT OF THE EXHIBIT.

The exhibit of The Lehigh University at the World's Columbian Exposition is located in the south-west gallery of the main building devoted to Manufactures and Liberal Arts. It is in the section assigned to the educational exhibits of Pennsylvania, and on the south side of the main aisle which traverses the gallery from east to west. Its official number is 9951.

The space assigned to the exhibit is a floor area of 19 feet by 19 feet. Around this are three side walls ten feet in height, the north side, which adjoins the aisle, being left open. A spur partition, eight feet high and eight feet long is built out from the middle of the south wall. The wall space of the exhibit aggregates about 620 square feet.

A show case eight feet long and three feet high, with glass top and sides, is placed near the front of the space and parallel with the aisle.

On the eastern part of the south wall are hung the photographs Nos. 1–10 and Nos. 193–196, and on the western part photographs Nos. 11–20 and Nos. 197–200.

The east wall is covered with framed drawings of the department of Civil Engineering Nos. 201–236, and the index, or statement of drawings done by students, No. 299.

The west wall is covered with framed drawings of the department of Metallurgy Nos. 401–431, 435, 436, 438, 439, 442, and the index or explanation No. 445.

The spur partition contains the frames of maps, charts and statistics Nos. 31–42, No. 152, also eight drawings by students in Civil Engineering and Architecture No. 238–244, 276, 277. The registry book No. 501 and a small bulletin board are on the western side of this partition.

The top of the show case contains the exhibits of the department of Chemistry No. 301–326. On shelves on the sides of the case are placed the books and pamphlets Nos. 45–48, Nos. 52–151, Nos. 181–190, and the students note books, sets of drawings and theses Nos. 154–178, Nos. 247–292, Nos. 432–451, and also the banner No. 191.

It should be said that Nos. 52–132 embrace only a part of the publications of professors, instructors, and alumni. A more complete list of such publications is contained in No. 502.

The students' work which is shown has been made in the regular courses of instruction, not a single piece having been specially prepared for this exhibit.

THE CLASSIFICATION OF KNOWLEDGE.

One of the most melancholy things in connection with intellectual work of every description, is the thought that we must inevitably forget so many valuable facts that we have toiled to grasp and let so many ideas perish almost in the moment of their inspiration, because we can not make use of them at the time when they occur to us. We are willing to labor, and think nothing of the cost of knowledge, if we may only have it at our command when we need it. It seems sheer waste to devote so much time to its acquisition if the result is going to be, that we are constantly becoming the possessors of real treasures which we can not retain. The fact is, that too much of our study leads to this result, especially in the case of books which we do not review as text-books and so are unable to fix upon the memory with that accuracy which can alone make their contents really useful to us. Few books which have been carefully read can be said to leave no residue in the mind after their perusal; but then, unless we are in absolute possession of the details, we do not dare to quote them with certainty or base important calculations upon this sort of information. It is one thing to understand a calculation or demonstration when the volume lies before us, and a totally different thing to recall it a month afterwards. This class of reading, as compared with the text-book study, is like writing in pencil on the block of marble, instead of using the chisel to engrave it fast and sure. The other duties of life and the subsequent subjects of reading make its outlines more and more illegible, until we hold a mere suggestion of the thing that was so clear and distinct a short time before.

Now we may well ask whence comes it that we can so easily forget, and must we always labor on feeling that so much will slip from our grasp? Can it be that this imperfection of attainment must follow us all through our professions? If so how can we ever hope to really master a subject? These are momentous questions and ones which affect our future success and are, therefore, well worthy of our careful consideration.

A century ago, when books were scarce and newspapers were only beginning to rise into view, men had fewer books upon a given professional subject, and these were read more thoroughly. The records of scholarship show men who had a marvelous grasp of a particular topic or science. Now-a-days all is changed. No man can do more than pass over, cursorily, much that is written in his own field; and he must soon divide all the literature in this field into two classes, those books which, on account of their great value to him, need to be conned again and again like college text-books are, and that larger body of works which are worth reading and comparing for the suggestions or statements which they contain, and yet can not claim the importance of the first division. No man can afford to disregard anything in his line, for he may meet with a single statement in a treatise which may be a seed thought to him in a great and important direction. We shall, therefore, find it worth while to discuss in brief how we may save this unfortunate waste of labor, which is so disheartening.

In the first place we shall find that we can gain much more from a book that we are reading, if we make an abstract of the main points as we proceed. Many writers, along with the results of their own investigations, go over old ground which we already are familiar with, and the abstract will thus give us the cream of the work in a shape where we can easily handle it and refer to it quickly, when we wish to make use of it. The conscious act of condensing the arguments is itself a good test of our real understanding of the writer's meaning, and will sometimes reveal to us that we have missed the point of a discussion. If we read this digest over before laying it aside, it will be a species of review of the whole that will help to fix many facts which would otherwise quickly fade away from our memory. The ancient naturalist Pliny was in the habit of doing this with every author he read, and accumulated a series of note books which represented many years of study.

But, in addition to the general outline of a given work, there are apt to be quotations or short references which we desire to preserve for ready use. This can best be done by having on hand a quantity of slips of thick writing paper, either in single sheets

or in pads. These should all be of a uniform size, for a reason which will be explained later. This slip may be covered with writing on both sides but the first page should have a space at the top for the classification number; and the title of the work from which the quotation is made should come at the head and be underlined, so as to catch the eye at a glance. A reference in the body of the abstract could not be classified under the appropriate head, and much time would be lost in hunting for it, with the chance that one might not remember which work contained it.

The device just mentioned is admirable, too, for cataloguing facts from magazine articles, and, when combined in a systematic way, gives the student the benefit of an accumulation of a great deal of reading. Furthermore, where several men are working together in a firm or in a scientific society, the resulting set of notes can be of inestimable value, for we have in this way all the advantages of collaboration.

But it may appear to some that the old method of an Index Rerum, or even a series of note books, would be preferable. This is, however, less practical, because of the difficulty of indexing such notes properly, unless a catalogue is made, which would not be as simple as the plan now under discussion. If we can not expect to be able to recall everything we need, we must have our notes so arranged that we can reach in a few minutes all that we have collected; and no book could be planned beforehand so as to assign sufficient space for all needs and yet leave no blank pages to be handled everytime we consult the catalogue.

Besides the notes and abstracts, we obtain a large number of items in the shape of clippings from the newspapers, and our system should provide for these also. The best thing for these as well as for the abstracts is a set of strong manilla envelopes large enough to contain anything which we could desire to put into them. The Boston Library Bureau, No. 146 Franklin Street, Boston, manufactures a set which consists of one hundred stout envelopes 5¼x9¼ inches, all numbered and in a strong box. These are large enough to contain quite a lot of clippings, but not for abstracts also, which might be too bulky. Still it is a simple matter to obtain such envelopes of any size which may suit the individual fancy.

Then, in addition to this, it is desirable to have the student's library, as it accumulates, catalogued upon cards, very much as the notes mentioned before. This may seem unnecessary to one just starting out, but pamphlets are rapidly gathered, and any one will soon find that he will forget such things very easily. The only way is to have the whole matter as methodical as possible from the start, and then the student will not become aware some day that he has a great mass of treasures which are useless because they are in disorder. This portion of our plan is, perhaps, less important at first, but should be added finally.

Thus we shall have a set of cards for our notes and another for our libraries, and a corresponding set of envelopes to hold our slips and abstracts. The question will at once arise as to the best arrangement. This is nothing more than to settle which system of library classification is to be preferred. After considerable experience in library management, the writer is convinced that the one which is named after its inventor, Dr. Melville Dewey, is the most satisfactory in its results. At the risk of repeating what is generally known, it may be worth while to mention its principal features. It is based upon the prime numbers 0 to 9, and employs them for the first figure, which stands for the general subject and may be made, by the addition of other figures to the right to form subdivisions, to go from 000 to 999. Thus the numbers 000 to 099 contains general subjects or special collections, 100 to 199 Philosophy, 200 to 299 Religion, 300 to 399 Sociology, 400 to 499 Philology, 500 to 599 Science, 600 to 699 Useful Arts, 700 to 799 Fine Arts, 800 to 899 Literature, 900 to 999 History and its kindred topics.

This arrangement may seem arbitrary, but any system will lie open to the same objection, and the gain in using numbers instead of letters or words will be readily appreciated when we begin to calculate the saving in labor. Then, too, there are certain mnemonics which apply in parts of the series which simplify the memorizing of the portion that we use. The thousand different heads will be quite sufficient for any ordinary worker, and for many persons a hundred will suffice. The list of a hundred is as follows:

1–9. General Collections or Special Topics.
10. Philosophy.
11. Metaphysics.
12. Methaphysical Topics.
13. Mind and Body.
14. Philosophical Systems.
15. Mental Faculties.
16. Logic.
17. Ethics.
18. Ancient Philosophers.
19. Modern Philosophers.
20. Religion.
21. Natural Theology.
22. The Bible.
23. Doctrinal Theology.
24. Practical and Devotional.
25. Homiletic.
26. The Church — Institutions and Work.
27. Religious History.
28. Christian Sects and Churches.
29. Mythology and Ethnic Religions.
30. Sociology.
31. Statistics.
32. Political Science.
33. Political Economy.
34. Law.
35. Administration, War.
36. Associations and Institutions.
37. Education.
38. Commerce and Communication.
39. Customs and Folk-Lore.
40. Philology.
41. Comparative Philology.
42. English Philology.
43. German "
44. French "
45. Italian "
46. Spanish "
47. Latin "
48. Greek "
49. Other Languages.
50. Science.
51. Mathematics.
52. Astronomy.
53. Physics.
54. Chemistry.
55. Geology.
56. Paleontology.
57. Biology.
58. Botany.
59. Zoölogy.
60. Useful Arts.
61. Medicine.
62. Engineering.
63. Agriculture.
64. Domestic Economy.
65. Communication and Commerce.
66. Chemical Technology.
67. Manufactures.
68. Mechanic Trades.
69. Building.
70. Fine Arts.
71. Landscape Gardening.
72. Architecture.
73. Sculpture.
74. Drawing and Decoration.
75. Painting.
76. Engraving.
77. Photography.

78. Music.
79. Amusements.
80. Literature.
81. American Literature.
82. English "
83. German "
84. French "
85. Italian "
86. Spanish "
87. Latin "
88. Greek "
89. Miscellaneous Literature.
90. History.
91. Geography and Travels.
92. Biography.
93. Ancient history.
94. Mediæval "
95. Asia.
96. Africa.
97. North America.
98. South America.
99. Oceanica and Polar Regions.

We are not confined to the numbers between 000 and 999, for if we wish to subdivide a given subject more minutely so as to classify the smaller topics in our own profession, we can introduce a decimal point after the whole number of the classification, and use as many decimal places as we choose to mark out. In the large volume upon this system, which is published by the Boston Library Bureau, we shall find that this work has been already done by experts in the various sciences, and the index to the list contains every species of title with the corresponding classification number. A student who desires to obtain the minuter subdivisions for his private set of notes can easily copy the heads from the full work which will be found in most large libraries. So many public libraries are catalogued upon this plan that it will be a great assistance to the use of their catalogues if we understand this system thoroughly. Its advantages are numerous, and it admits of placing the rows of books consecutively according to the numbers and it causes no trouble in arrangement when new books are indroduced, for the others merely need to be moved along, and the succession of numbers keep the volumes in proper order without the assignment of alcoves to one large section.

There are many works which it is difficult to assign to a head because they include several subjects, and the beginner will meet with this problem at the very outstart; he must reflect, however, that this objection would apply equally to all systems of library classification, and can only be met by placing the book in that division to which the more important part belongs. He will be

assisted in this by the fact that the general section of a series of ten (or of one hundred, if we are using the thousand heads) is intended for works which cover several sub-sections. For example, if a man wishes to classify a collection of prose essays which contains the work of both English and American writers, he may be puzzled to know whether it should go under 81 or 82 (or if we employ the fuller classification 814 or 824). He will settle this by numbering it 80 (or 804) because the 0 at the end of a number indicates that it includes all the subdivision under that column of ten. Did space permit, it might be profitable to give a fuller description of the method of analysis, but any one who is interested in the subject can obtain full information from the complete index in the library, and thus work out a series for himself.

Now, it will usually happen that a student will not be likely to need all the set of divisions, because he may not care to collect notes in more than a few directions, and right here lies the chief value of the Dewey system; for a man can disregard the subjects which do not belong to his plan and can either omit them altogether, or group them under the most general head, as, for instance, to include all items referring to Religion under 200, of those belonging to Art under 700, and so on; while he can run the subdivision of his specialty to the fifth place of decimals, if he so incline.

It is a practical device to take paper, cut the size of the cards, and make out in a neat, small lettering the heads of classification which we desire to use. Let this stand in the file of cards, which may most conveniently be kept in order on edge in a box or in a drawer of the worker's desk. Then, when a reference has been made on a card, write the classification number in the upper left hand corner and place it in its position in the row of cards, and you have the item ready for future reference. One great advantage of the separate cards is, that, when we have used the particular fact, we can remove the slip, and thus it will not swell the pages to be turned over in order to find something else.

But some one may consider this a great deal of trouble, and may think that it is possible to do just as well without such a system. If he will invent another equally good, then he can dis-

regard this discussion; but the great advance which has been made in all descriptions of work consists in an increase of speed and accuracy, by enabling a worker to save the time which was formerly lost between different portions of the operations. The gangs of artisans do this, and so have increased the production enormously. So, too, in intellectual effort, the like economy of time and improvement of results will follow from having the tools always at hand for use; and the mind will be taught the necessity for a clearer and more exact grasp of each subject as it comes up. Only in this way can we hope to accomplish our full share of the world's progress; for the years are few that a man may expect to be able to labor, and the energetic will take advantage of any short cut that will eliminate the waste which is so discouraging, and guard against the half knowledge which destroys the value of so much that we do. E. M. HYDE.

MODERN VIEWS ON JOURNAL FRICTION.

BY PROFESSOR F. RELEAUX.

TRANSLATION FROM THE GERMAN BY KARL P. DAHLSTROM.

It is not our intention, as appears to be the custom at the present day, to oppose established theories by presenting entirely new doctrines. But it is a well-known fact, that experience has proved the old theory of friction to be untenable, and we therefore deem it necessary to familiarize practical men with the views on the subject which have long been held by scientists. The development of the theory of friction has been going on for a long time in Germany, and it is here only proposed to furnish an additional contribution. As a marked contrast we may mention that in France, where the original friction theories were created, the old views of Coulomb and Morin are still adhered to. According to the latter authorities, the sliding friction would be:

1. Proportional to the pressure.
2. Independent of the sliding velocity.
3. Independent of the size of the surfaces of contact;

while according to more recent experiments, it actually is

1. *Not* proportional to the pressure.
2. *Dependent* on the sliding velocity.
3. *Dependent* on the intensity of pressure.

It will no doubt be unwelcome to many to be obliged to give up Morin's so-called "laws" of friction, which were so convenient, and in their stead adopt a much more complicated theory. But nothing else remains to be done in dealing with such important technical problems as train resistance, wear of journal bearings, the action of brakes, etc.; the discrepancies are too great. For instance, the coëfficient of friction for wrought iron with well lubricated surfaces, does not remain unaltered at 0.14, as Morin concludes, but varies from 0.14 to 0.40 when the pressure is increased to 15 times that employed by Morin in his experiments; and this 15-fold pressure is commonly met with in practice. According to Morin, a 15-fold pressure would increase the friction 15 times, while, as a matter of fact, the increase is nearly 43-fold.

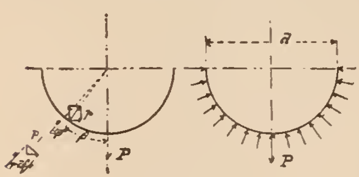
Moreover, the experiments made in 1879 by Douglas-Gaston, now president of the British Institution of Civil Engineers, have shown that when the sliding velocity increases 13 times (or the speed of a train from 2 meters to 26 meters [6½ to 84½ ft.] per second) the coëfficient of friction gradually diminishes from 0.330 to 0.074, or to less than ¼ of the former value. Besides, the same experimenter has observed that, in the case of brakes, the duration of contact has a decided influence on the amount of friction generated, which is a matter of considerable importance in this instance. It was found that the friction, or coëfficient of friction, decreased from the value 0.18 at the beginning of the experiment

to	0.15	0.13	0.12	0.10
after	5	10	15	20 seconds.

Such variations must not be neglected, and therefore Morin's theory will no longer suffice, or, to express the matter with more caution, in the field above indicated it is applicable only *within certain limits*. These limits, which would exclude the necessity of using more complicated formulas of general application, are very narrow and must be determined in each particular case by special experiments. It therefore appears necessary, as is frequently done, *to give the friction experiment a place in the series of laboratory tests* to which constructive materials are now usually subjected.

A theory has been advanced in France for the special case of journal friction. It assumes that the diameter of the bearing always is slightly larger than that of the journal, so that the contact always takes place along a generatrix near the plane in which the pressure acts. The frictional resistance F at the circumference of the journal would then approximately equal Pf, if P is the load and f the coëfficient of friction. This theory also does not hold, inasmuch as, when the direction of pressure remains unaltered, the journal merely wears the box oblong without enlarging its diameter, and besides it is based on the erroneous supposition that the intensity of pressure is without influence. The value $F=Pf$ obtained is too small. To be sure, in a number of practical applications of the formula this has proved to be of no detriment, since all that was necessary was to assume a greater coëfficient of friction; but in many important instances the formula fails to account for the experimental results obtained.

The direction in which a more accurate discussion of the subject should proceed was first pointed out by Reye,* whose method will here be pursued, though it is carried still farther and presented in a somewhat different form. When a cylindrical journal rests in a semi-cylindrical bearing, which is arranged symmetrically with reference to the unchanging direction of pressure (Fig. 1), then the pressure against the journal at an angle β from the axis of symmetry will be $p\, r\, d\beta\, l$, if p is the pressure per unit area, r the radius, and l the length of the journal. Of this force only the component, which is parallel to P, offers resistance to the latter, while that which is perpendicular to the former is counteracted by the component which acts symmetrically opposite. We, therefore, have:



FIGS. 1 and 2.

$$P = \Sigma\, p\, r\, d\beta\, l \cos\beta, \text{ or } = 2\int_0^{\frac{\pi}{2}} p \cos\beta\, d\beta\, r\, l,$$

* Reye, "Zur Theorie der Zapfenreibung," Civ.-Ing. VI, (1860) p. 295; also Grove, "Berechn. der Trag- und Stützzapfen," Mitt. d. Gew.-Vereins f. Hannover, 1876. Heft 6.

where it still remains to determine the relation which p bears to β. On the horizontal projection of the strip $l\,r\,d\beta$ the pressure per unit area is:

$$\frac{p \cos\beta\ r\ d\beta\ l}{l\ r\ d\beta \cos\beta},\ i.\ e. = p,$$

or, expressed in words, the intensity of pressure at the circumference is independent of β and constant (fig. 2), being equal to the intensity of the pressure on the horizontal projection of the bearing surface. For a diameter d of the journal, we therefore have:

$$p = \frac{P}{l\,d}.$$

This peculiar relation shows in the first place how erroneous is the widespread opinion that a wedging pressure of some magnitude acts at the upper edges of the box, and in the second place it tells us that the journal friction acts quite differently from what Morin (and with him Poncelet) supposed. For, the tangential force F at the circumference, which is in equilibrium with the friction, will now be given by:

$$F = f\,p\,\frac{\pi}{2}\ l\,d = f\,\frac{P}{l\,d}\,\frac{\pi}{2}\,l\,d = f\,\frac{\pi}{2}\,P = 1.57\ f\,P,$$

which is more than 1½ times the result obtained from the old formula.

This expression, however, is *only applicable to new journals*, inasmuch as experience shows that, under the above supposition of unchanging direction of pressure, the journal in the course of its running sinks into the box, Fig. 3. If the journal is much harder than the bearing, its wear will at the same time be so slight that the amount may be neglected. When the depression has reached the value u, the amount of wear radially at the angle β will be $u' = u \cos\beta$.* The intensity of pressure p' at the angle β will

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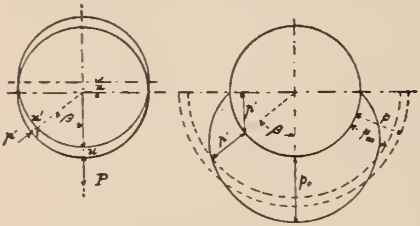
* Strictly speaking this is only true when u is infinitesimal, but the total amount of wear may be considered as made up of a series of such infinitesimal values, whence the above sufficiently accurate value follows.

therefore be smaller than for $\beta = 0$.



FIGS. 3 and 4.

Evidently u' is proportional to the work done by the friction at the corresponding surface element, and consequently per unit of time we can place $u' = p' \, v \, f \, \sigma'$ and $u = p_0 \, v \, f \, \sigma$, if v is the circumferential velocity and σ a value depending on the material and lubrication. For each particular journal we can without hesitation place $' = \sigma$ and then obtain

$$\frac{p'}{p_0} = \frac{u'}{u} = \cos \beta .$$

This shows that the intensity of pressure between the journal and its bearing decreases from the bottom towards the upper edges where it is equal to zero, and we see once more that the theory of a wedging action at these points is without foundation. The increase and decrease of intensity of pressure may be represented graphically in several ways. We will here choose the method of letting the intensity p_0 at the bottom be represented by the radius r. Then we shall have $p' = r \cos \beta$, and the extremities of the radial lines which represent the intensities will be located on a polar curve whose equation is

$$\rho = r + r \cos \beta$$

i.e., on a *cardioid* (Fig. 4).* The sum of the vertical components of all the intensities p must now equal P, *i.e.*, $= p \, l \, d$, or

$$p \, l \, d = \Sigma \, p' \cos \beta \, l \, r \, d\beta = 2 \int_0^{\frac{\pi}{2}} p_0 \cos^2 \beta \; d\beta \; l \; \frac{d}{2} = p_0 \, l \, d \, \frac{\pi}{4};$$

hence we have

$$\frac{p_0}{p} = \frac{4}{\pi} = 1.27,$$

* More particularly a "pericardioid," (see *Releaux:* Konstrukteur. 4 Aufl., S. XLV,)

or $p = \frac{\pi}{4} p_\circ = 0.785\, p_\circ = 0.785\, r$, which value is introduced in the figure.

It is also desirable to ascertain the average intensity p_m, which acts radially on the semi-cylindrical surface with the same effect as the force p' that varies from 0 to $p_\circ$. We have

$$p_m \pi l r = 2 \int_0^{\frac{\pi}{2}} p_\circ \cos \beta\, r\, l\, d\beta = 2\, p_\circ r\, l,$$

and hence

$$p_m = \frac{2}{\pi} p_\circ = \frac{8}{\pi^2} p = 0.81\ p.$$

From this we see that the friction of journals which have worn down in their bearings is less than that of new journals. For, the value p_m represents a uniform intensity of pressure distributed over the semi-cylindrical surface of the bearing, as did p in the case of new journals, and consequently the friction will be correspondingly reduced to the amount

$$F' = \frac{8}{\pi^2} F = \frac{8}{\pi^2} f \frac{\pi}{2} P = \frac{4}{\pi} f P = 1.27\, f P.$$

This value is still over one and one-fourth times as large as that obtained from the old theory. It will be noticed, however, that when the journals of a machine are "worn in," the frictional resistances will be reduced by a considerable amount, theoretically about 20 per cent. In practice the reduction is, as a rule, still greater since the surfaces in contact become polished, provided that the lubrication is good and the intensity of pressure not too great.

If, under this supposition, we desire to compute the friction for a journal having a *semi-cylindrical* bearing, more especially with reference to practical purposes, we must transform somewhat the expressions for F and F'. If the diameter of the journal is expressed in millimeters, the velocity at the circumference, in meters per second, will be $v = \frac{n\ \pi\ d}{60 \times 1000}$ where n denotes the

number of revolutions per minute $\left[v = \frac{n \pi d}{60 \times 12}\right.$ feet per second, when d is given in inches]; consequently, for *new journals*, the frictional effect will be:

$$F v = \frac{\pi}{2} P f \frac{n \pi d}{60000} = \frac{\pi^2 P f n d}{120000} \text{ meter kilograms, } \left[F v = \frac{\pi^2 P f n d}{1440}\right.$$

foot pounds] or approximately

$$F v = \frac{P f n d}{12000} \text{ m. kg, } \left[F v = \frac{P f n d}{144} \text{ foot lbs.}\right]$$, while for inworn journals we find $F' v = \frac{4}{\pi} \frac{P f n \pi d}{60000} = \frac{P f n d}{15000}$ m. kg, $\left[F' v \frac{P f n d}{180}\right.$ foot pounds.) The old theory gave for both cases

$$F v = \frac{P f n \pi d}{60000} = \frac{P f n d}{19100} \left[F v = \frac{P f n \pi d}{720} = \frac{P f n d}{229}\right],$$

which value is much too small, as has already been noted. To express the effect in horse-power we only have to divide by 75 [or 550] and thus, for the most important case or for *inworn journals*, we obtain the horse-power N_f required to overcome the friction to be:

$$N_f = \frac{F' v}{75} = \frac{P f n d}{75 \times 15000} = \frac{P f n d}{1152000} \left[N_f = \frac{P f n d}{180 \times 550} = \frac{P f n d}{99000}\right]$$

or, written in a more convenient form,

$$N_f = \frac{8}{9} \frac{P f n d}{1,000,000} \quad \left[N_f = 1.01 \frac{P f n d}{100,000}\right]$$

Example 1. Assuming $P = 3300$ kg [7277 lbs.], $d = 65$ mm., [2.56 ins], $n = 100$, $f = 0.08$, then we have $N_f = \frac{8}{9} \times 3300 \times 0.08 \times 100 \times 65 \div 1,000,000 = 45,760 \div 30,000 = 1.525$ *P. C.* [1.504 H.P.] [$N_f = 1.01 \times 7277 \times 0.08 \times 100 \times 2.56 \div 100,000 = 1.505$ H.P.]

Example 2. Locomotive driving axle journals. $P = 6000$ kg [13230 lbs.], $d = 200$ mm. [7.87 ins.], $n = 200$, $f = 0.08$ will give $N_f = \frac{8}{9} \times 6000 \times 0.08 \times 200 \times 200 \div 1,000,000 =$

$64 \times 8 \div 30 = 17.067$ *P.C.* [16.83 H.P.]; [$N_f = 1.01 \times 13{,}230 \times 0.08 \times 7.87 \times 200 \div 1{,}000{,}000 = 16.83$ H.P.] In a locomotive with four driving wheels the friction due to the load on the journals alone will therefore equal $4 \times 16.83 = 67.32$ H.P., apart from that generated by the horizontal pressures exerted by the pistons. Since the coëfficient of friction at the instant the journals are set in motion, or when the velocity at the circumference is slight, materially exceeds that which applies to greater velocities, it is evident that the power required to start the locomotive will be very considerable, which is also a well-known fact. New journals would require $1\frac{1}{4}$ times the power just computed; the result obtained from the old theory would be 4-19 or about 21 per cent. too small.

Example 3. A fan or ventilator is driven at the rate of 2400 revolutions per minute. If the journals are 50 mm. [1.97 in.] in diameter, and the total pressure on both bearings is 216 kg [476.23 lbs.], then the velocity will be $v = \pi \times 2400 \times 50 \div 60 \times 1000$, *i.e.* over 6 m. [20 ft.] per second, and, therefore, the coëfficient of friction will be very small, say $f = 0.04$. We then obtain $N_f = \frac{8}{9} \times 112 \times 0.04 \times 2400 \times 50 \div 1000000 = 0.93$ P.C. [0.92 H. P.], which shows that for wheels of this kind the journal friction is of but little consequence.

In the above discussion we have assumed a semi-cylindrical contact, which, however, covers but a single practical case, since ordinarily the surface of contact is reduced by the application of oil grooves, both at the sides and bottom of the bearing. Assuming that at the bottom a portion of the circumference corresponding to the angle $2\beta_0$, and at the sides one represented by the angle $90-\beta_1$ (Fig. 5), remain untouched by the journal, then we should have to substitute for 0 and $\frac{\pi}{2}$ in the above calculation the limits β_0 and β_1. We thus obtain:

FIG. 5.

$$P = 2\,r\,l\,p_0\left(\frac{\beta_1 - \beta_0}{2} + \frac{\sin\beta_1\cos\beta_1}{2} - \frac{\sin\beta\cos\beta_0}{2}\right).$$

If, as before, we let p denote the intensity of pressure on the total projection of the journal, we have $P = 2\,r\,l\,p$, which, substituted in the last formula, gives

$$\frac{p_0}{p} = \frac{2}{\beta_1 - \beta_0 + \sin\beta_1\cos\beta_1 - \sin\beta_0\cos\beta_0}.$$

As was to be expected, this expression shows a material increase of p_0 and, consequently, also of p', which is a matter of importance as regards the amount of friction. For determining the average intensity p_m, which, as before is supposed to be uniformly distributed over the semi-cylindrical surface, we now have:

$$p_m \pi\, r\, l = 2\int_{\beta_0}^{\beta_1} p_0 \cos\beta\, r\, l\, d\beta\,.$$

For a given pressure p_0 this gives

$$p_m = \frac{2}{\pi}\, p_0\,(\sin\beta_1 - \sin\beta_0),$$

or, when we substitute the value of p_0 found above:

$$p_m = \frac{4}{\pi}\,\frac{\sin\beta_1 - \sin\beta_0}{\beta_1 - \beta_0 + \sin\beta_1\cos\beta_1 - \sin\beta_0\cos\beta_0}$$

Hence we can now compute the friction for journals with less than semi-cylindrical contact from the formula:

$$F'' = f p_m \frac{\pi}{2}\, d\, l = f\,\frac{p_m}{p}\, p\, d\, l,$$

or

$$F'' = f\frac{\pi}{2}\,\frac{p_m}{p},$$

where we only have to introduce the ratio of p_m to p found above in order to obtain the friction. Comparing this value with the friction F' of inworn journals with semi-cylindrical contact we have for identical f

$$\frac{F''}{F'} = \frac{\pi^2}{8}\,\frac{p_m}{p}.$$

But the ratio $p_m : p$ decreases with a reduced contact, a result which at the first glance would not have been expected, and consequently *the reduction in contact corresponds to a smaller amount of friction.* The table given below shows the ratios of intensities of pressure, as derived from the formulas for varying angles of contact. The increased intensity of pressure on the projected area of the journal due to decreasing contact is a matter worthy of note. It evidently becomes greater than p, as seen from the equation

$$P = 2\,p_1\,r\,l\,(\sin\beta_1 - \sin\beta_0) = 2\,p\,l\,r$$

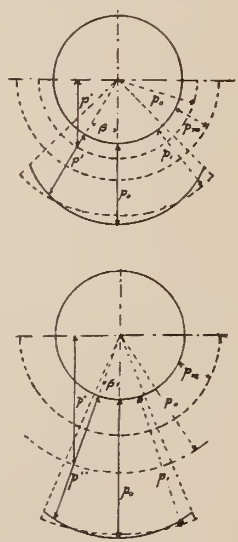
whence follows:

$$\frac{p_1}{p} = \frac{1}{\sin\beta_1 - \sin\beta_2}.$$

VALUES OF INTENSITIES p_0, p_m AND p_1.

$\beta_1 =$	90°		75°		60°		45°		30°		22½°	
$\beta_0 =$	0°	5°	0°	5°	0°	5°	0°	5°	0°	5°	0°	5°
$\frac{p_0}{p}$	1.27	1.43	1.28	1.45	1.35	1.53	1.56	1.80	2.08	2.54	2.68	3.50
$\frac{p_0}{1.27\,p}$	1.00	1.12	1.00	1.14	1.06	1.20	1.22	1.41	1.63	2.00	2.10	2.75
$\frac{p_m}{p}$	0.81	0.84	0.79	0.83	0.74	0.76	0.70	0.71	0.66	0.67	0.65	0.66
$\frac{p_m}{1.27\,p}$	0.64	0.66	0.62	0.65	0.58	0.60	0.54	0.55	0.52	0.52	0.51	0.52
$\frac{p_1}{p}$	1.00	1.10	1.04	1.14	1.15	1.28	1.41	1.61	2.00	2.42	2.62	2.38
$\frac{p_1}{1.27\,p}$	0.79	0.86	0.82	0.98	0.90	1.00	1.10	1.27	1.57	1.90	2.06	2.65

To facilitate the survey, the intensities of pressure for $\beta_1 = 45°$ and 22½° are represented graphically in Figs. 6 and 7 in the following manner: A circle of radius p_0 is drawn which is to the radius of the journal as $p_0 : 1.27\,p$ (second line of the table). The perpendiculars drawn from the circumference of this circle to the horizontal diameter will then represent the values of p_1 (we have $p^1 \div p_0 = \cos\beta$), which are afterward set off radially from the circumference of the journal.



FIGS. 6 and 7.

We now arrive at the practical conclusions which can be drawn from the above investigation and will then first point out what has already been done in practice independent of this theory. It is a well-known fact that in railroad practice a decreased angle of contact has long been in use, inclusive of the cutting away of a portion of the brasses in the shape of oil grooves. As

the journal friction forms such an important element of the train resistance, it is evident that practice has proceeded in the right direction, *which, however, is contrary to the old theory.* Again, in rolling mills it has for a long time been customary to employ a small angle of contact, of from one-fourth to one-eighth of the circumference. The new theory proves that this practice is commendable. For in view of the fact that a very great amount of power is here consumed in a short space of time, it is evident that the consequent reduction of 15 to 16 per cent. in friction is a matter of great importance.

Also in locomotives, where from 70 to 80 horse-power are spent in overcoming friction at the driving axles, a saving of power might be effected by decreasing the angle of contact of the journals. The horizontal stress due to the train resistance could be provided for to best advantage by the use of special narrow boxes. Such separation of the boxes to resist the pressure due to weight and transmission of power is often seen in stationary engines of the horizontal type, and even for the latter class of engines a further reduction of the arc of contact would, no doubt, be advantageous.

In all these constructions of journal bearings, the coëfficient of friction is dependent on the intensity of pressure, or the pressure per unit area, and the latter is, therefore, not to be chosen too great if good results are to be expected. When the load always acts in one direction, p should not much exceed ½kg per square millimeter (700 lbs. per square inch); the better plan, however, is to keep it below this limit, when it is possible to do so.*

It now remains to ascertain whether the conclusions drawn from the above new theory are corroborated by practical experiment, apart from the indirect demonstration furnished by the facts mentioned. For this purpose a testing instrument is required which must combine simplicity of construction with ease of manipulation. An apparatus of the kind is the *friction pendulum*, designed by the author, and shown in Fig. 8.

* In Morin's experiments the pressure per unit area was from 1-40 to 1-10 kg per square millimeter only (from 35 to 142 lbs. per square inches), which explains why his conclusions have no general application.

The journal Z, which is to be tested in regard to friction, forms a part of a small spindle which runs freely in its bearings, and is loaded in such a manner, by means of a pendulum provided with a heavy bob P, that the resultant of all the forces acting upon it passes through the middle of the journal; the small auxiliary journal Z' will, therefore, be nearly without load. The bearing is so arranged that it embraces one-half of the journal on one side, while on the opposite side the contact is much smaller—for instance, one-twelfth part of the circumference. By means of a lever, H, attached to the bearing (which is made in the shape of a cylindrical bushing), it is made possible to bring the vertical pressure on one or the other of these arcs of contact. Stops are introduced which limit the stroke of the pendulum to exactly the same angle for each experiment, and thus admit of a fixed amount of living force being communicated to it. It is only necessary to count the number of oscillations made by the pendulum from the moment it is released until it stops. The resistance of the air may be neglected. The number of oscillations is then evidently proportional to the frictional resistance at the journal Z. Usually rest is attained after 15 to 30 oscillations. As a matter of fact, the ratios of the number of oscillations corresponding to either position of the bearing agree remarkably well with the values $p_m : p$ given in the above table. The friction pendulum may also be utilized for numerical determination of the coëfficients of friction by the introduction of boxes made of different materials, and subjecting them to different intensities of pressure with different lubricants.

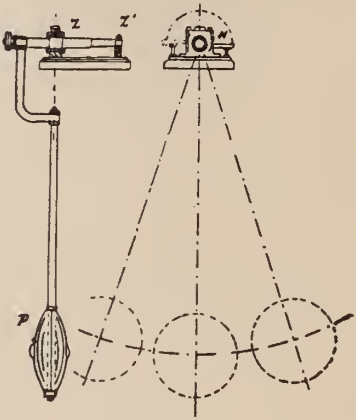


Fig. 8.

In this connection another important investigation may be made, namely, with reference to the *amount of material that wears away from the bearing for different angles of contact.*

According to the preceding discussion, this amount is, in the case of semi-cylindrical contact, given by

$$u = p_0 f v \sigma$$

and for a smaller surface of contact, by

$$u_1 = p_0' f v \sigma$$

if p_0' denotes the intensity of pressure corresponding to an angle of contact $2(\beta_1 - \beta_0)$. We consequently have

$$\frac{u_0}{u} = \frac{p_0'}{p_0}.$$

But the amount of materials worn away per unit of time is proportional to the projected bearing surface and accordingly we have for semi-cylindrical contact

$$s = u\, 2\, r$$

and with less bearing surface

$$s_1 = u_1\, 2\, r\, (\sin \beta_1 - \sin \beta_0),$$

or, after substituting the values found above

$$\frac{s_1}{s} = \frac{p_0'}{p_0} (\sin \beta_1 - \sin \beta_0).$$

Combining this equation with the relation previously found:

$$\frac{p_1}{p} = \frac{1}{\sin \beta_1 - \sin \beta_0}$$

we now obtain

$$\frac{s_1}{s} = \frac{p_0'}{p_0} \frac{p}{p_1}.$$

If we calculate this ratio from the numerical values given in the above table, we obtain the following:

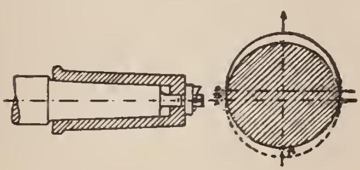
COMPARISON OF WORN OFF MATERIAL.

$\beta_1 =$	90°		75°		60°		45°		30°		22½°	
$\beta_0 =$	0°	5°	0°	5°	0°	5°	0°	5°	0°	5°	0°	5°
$\frac{s_1}{s}$	1.00	1.02	0.97	1.02	0.92	0.94	0.87	0.88	0.81	0.82	0.81	0.81

Hence we note the remarkable fact that for $\beta_0 = 0$ a reduction in the angle of contact is *always* accompanied by a decreased amount of wear, while for the case that the bearing at the middle has a groove 10° wide, only in two instances (for $\beta_1 = 90°$ and 75°) an increased wear is occasioned. We can, therefore, conclude that, with reference to this point also, the increasing practice of making car-axle boxes with *less than semi-cylindrical contact* is to be recommended.

The above investigation has reference to the case when the journal revolves, while the box remains at rest relatively to the direction of pressure. The reverse is not infrequently the case, however, as, for instance, in vehicles for ordinary roads where the axle is secured to the body, and the box in the shape of a bushing fits into the hub of the wheel, Fig. 9.

If no provision were made for taking up wear, and if we were to assume that the spindle alone could depreciate, the latter would gradually change its shape into that shown in Fig. 10, as is sometimes seen in poorly kept wagons. It is well known, however, that usually the spindle and bushing are made tapering, as in Fig. 9, so as to provide a means of taking up wear in the direction of the axis, and counteract the play which is very apt to occur, owing to the fact that the bushing is of a softer material than the spindle.



FIGS. 9 and 10.

It may finally be noted that the above discussion is still applicable when both bearing (Fig. 3) and journal are subjected to wear. The radius of the journal then gradually grows smaller as it sinks into the bearing, close contact always being maintained, contrary to the old theory. The value of r is then no longer constant, but will be the same in both sets of equations.

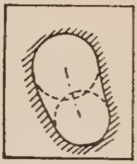


FIG. 11.

In the collection of machine details at the Technical School of Berlin, there is an inking-roller bearing from a printing press showing wear in the manner indicated by Fig. 11. It will be

seen that the journal diameter has materially decreased with the wear of the bearing, while at the same time the average direction of pressure has become altered. Also in the boxes of shaft hangers with too small bearing surface — *i.e.*, too great intensity of pressure, such oblique depressions due to the tension of the belts may occasionally be seen, though not in modern practice, owing to the large wearing surfaces usually adopted.

NOTES ON THE MANUFACTURE OF STEEL

BY THE

THOMAS-GILCHRIST PROCESS.

BY F. TOURDEUR, ENGINEER AT MONCEAU-SUR-SAMBRE.

A paper read before the Association des Ingénieurs sortis de l'Ecole de Liège. (Section de Charleroi.) Oct. 22, 1891. Translated by J. S. Robeson, April, 1893.

The Thomas-Gilchrist patent for the dephosphorization of pig iron in the Bessemer converter was granted March 15, 1879.

The Dowlais works were the first to use this process, commencing in 1879; Easton followed next, in the same year.

La Société d'Angleur bought the rights for Belgium, and has been dephosphorizing since 1879.

The Rhine Steel Works and the Hoerde Works together purchased the rights for Germany. The first heat was made in September, 1879, at the same time in both plants.

In France, the Société du Creusot dephosphorized in the early part of 1880.

The table below, taken from the *Moniteur des Intérêts Matériels* for 1891, and giving the production of basic steel for the whole world, shows that this process has extended more rapidly in Germany than in all the other countries of the world taken together:

Year Ending.	England. Metric Tons.	Germany and Luxemburg. Metric Tons.	Austria. Metric Tons.	France. Metric Tons.	Belgium, Russia. et. al. Metric Tons.	Totals. Metric Tons.
Oct., 1879,	1170	50				1220
" 1880,	10,000	18,180	13,754	4,771	3,295	50,000
" 1881,	46,120	200,000	54,700	10,480	24,700	336,000
" 1882,	109,364	235,132	62,214	12,306	28,984	450,000
" 1883,	122,380	328,909	85,593	38,229	59,262	634,373
" 1884,	179,000	440,000	80,300	113,000	51,700	864,000
" 1885,	145,707	548,252	69,262	130,582	51,514	945,317
" 1886,	258,466	784,212	99,647	122,711	48,595	1,313,631
Dec., 1887,	435,046	1,167,702	142,409	210,301	68,613	2,024,071
" 1888,	408,594	1,137,632	128,438	222,333	46,237	1,953,234
" 1889,	493,919	1,305,887	175,755	222,392	76,599	2,274,552
" 1890,	503,400	1,493,157	202,315	240,638	163,573	2,603,083
Totals,	2,713,166	7,659,113	1,126,387	1,327,743	623,072	13,449,481

It should be noted that up to 1886, the year was considered as ending in October. The figures for 1887, however, include beside the twelve months of that year, the last two months of 1886. Since that time the year has terminated on December 31.

One of the causes of the more rapid development of the process in Germany than in the other producing countries lies in the fact that at the works of the Société des Aciéries du Rhin, at Ruhrort, means were found for making the lining stronger, which previously had given away very quickly. Naturally this discovery spread very rapidly among the neighboring works.

The owners of the patent were, by the terms of their agreement with Thomas and Gilchrist, and on demand of their licencees, compelled to furnish them with all details of their practice.

In the beginning the bricks employed in lining the converters were made in the following manner: The raw dolomite was crushed, then moistened, forming a paste from which the bricks were made similarly to the ordinary house brick. After drying and burning the resulting bricks, of about one-third the original volume, were so twisted and deformed that at Rhurort they had several workmen who endeavored, by dressing the bricks with small chisels, to bring them to a uniform size and shape so that they might be laid one against the other.

In spite of all this care, the metal leaked through the joints during the blow, and sometimes the lining fell in during the heating up of the vessel.

The number of heats on such a lining varied from ten to fifteen. The bricks cost 125 francs a thousand kilo ($25.40 per 2240 pounds).

The bottom was made from the same bricks. It is easy to understand the difficulties that were met with in handling such a defective material, in endeavoring to make a cylindrical mass 1.2 m. in diameter in which dolomite tuyeres, often badly twisted during the burning, had to be set. It took two or three days to get the apparatus ready.

Later, needle bottoms of rammed dolomite were used, though for the converter lining itself the method just described was employed until the end of December, 1880.

Needle bottoms are those in which the tuyeres are replaced by openings one centimetre (3/8″) in diameter uniformly distributed through the cylindrical mass. The rammed mass (dolomite) was made of ground dolomite which had been fritted and afterwards mixed with ordinary tar.

Towards the end of 1880, great progress was made in production and cost by employing rammed dolomite for vessel linings. This was comparatively easy to put in and was fairly durable, but it had the disadvantage of requiring a good deal of time to put in place. At Rhurort they again tried bricks made on a plan which they discovered after numerous trials.

Ordinary basic mass was pounded into iron moulds, which were afterwards closed as tightly as possible with key bolts in order to prevent, first, any contact with the air before the burning; second, the combustion of the tar during the burning.

These bricks, owing to the absence of shrinkage, preserve their original form, hence the vessel linings can be put in very rapidly and stand very well. However, occasionally, the bricks would burst. It was discovered that this trouble was caused by the presence of ammonia in the tar.

The use of a tar previously distilled in order to render it free from water and ammonia, and of bricks weighing 25 kilo (55lbs.),

so that one man could still easily handle them, was, so to speak, the last step but one of progress that has been attained, as much as regards the life of the lining as of the rapidity of its construction. At Ruhrort, with vessels of six metric tons, the renewal of a lining causes an interruption of 17 hours in the blowing; the vessel life with several repairs was from 80 to 100 heats; today they reach 180 heats.

At present at the Rhine steel works at Ruhrort they make the lining with unburnt bricks that have been formed in a hydraulic press. This process is only applicable where they work very rapidly, since the bricks on being exposed to the air, fall into dust at the end of three days. The rammed mass is no longer used because it requires a longer time to put in place. Working with only two converters, it would be impossible to operate night and day without interruption.

With ten-ton converters it would be impossible to cool off the apparatus, tear out the lining, replace it and heat up the vessel without an interruption of at least 24 hours.

In order to do away with this delay, Holley devised a system which may be defined as follows: A building in which to make the linings and a building in which to use them. The application of this system seems to be rather difficult, since it has not come into general use. The Athus steel works, which are not now in operation, were built on the Holly plan. It is in truth not an easy thing to carry a converter weighing from 45 to 60 metric tons, and from 4 to 5 metres (13 to 16 feet) high from one building to another on a car with a short wheel base and on narrow gauge tracks. The base being small and the center of gravity often coming outside the center of the vessel, the carriage and its load are in danger of being thrown out of the perpendicular. The carriage and its charge would then be placed on the platform of a hydraulic ram located on the floor of the casting house under each converter, in order to raise the whole apparatus at once. It should be noted that the operation is always a double one. It is necessary, first, to take away one vessel, and then to put another in its place. A furthur difficulty, it seems to me, would be to maintain constantly in working order the hydraulic platform placed beneath the converter, since after each

operation it would undoubtedly receive the slag, which, spreading out into the open space between the platform and the pavement, would necessarily fasten the latter down.

Having studied this system, I believe that it may be modified in view of the following considerations: The lining of a basic converter requires partial and, so to say, periodic repairs on three different parts. The bottom section, while using up three or four bottoms, is renewed two or three times; the lower and middle sections, washed by the metal, are replaced simultaneously with the bottom section once or twice. The repairs to the belly and the nose depend on the more or less friable condition of the lime used. This latter, which should not be silicious, must sometimes stand a long railway journey. Dust is above all hurtful; mixed with the slag it sticks to the belly and nose, which in spite of the skulling after each heat, it finally closes up. This trouble is greater if the lime has commenced to fall when received. In spite of the care taken to clean it from dust, the lumps which appear to be entire will break up and form dust during the blowing of the heat if the lime has commenced to slake. It should be noticed that in concentric converters the slag rarely sticks to the nose, but on the other hand, the "throwing out" is more copious than in eccentric converters. The symmetrical form therefore appears to increase the loss; besides, in order to have the necessary capacity to prevent the iron from running out of the apparatus when it is placed in a horizontal position, it is necessary to increase its height, which still further increases the difficulties, besides adding to the amount of lining required. These facts being established, let us see how we can render Holly's idea practical. In order to do this, we will divide the converter into different parts, to wit: first, a bottom section containing the bottom; second, a bottom section and middle section. plus a certain height; third, the belly and nose. These different parts, previously lined, would be placed on a hydraulic car such as is usually used to replace bottoms, and could be put in position in their proper order. The delicate part of the operation would be, first, to prevent the different portions of the lining from falling out while the different parts of the converter are still separate; secondly, to preserve the smooth surfaces of the joints. In order to do this,

angle iron should be riveted to the apparatus at each joint, but not as wide as the lining is thick. Circles of wrought or cast iron formers, not adherent and varying in radial dimensions according to the more or less wear of the lining, would complete the arrangement.

If it is desired to put in place the entire apparatus cold, in sections, care must be taken not to crush the center section, and very solid formers must be used at this place in order that they may be able to support the overhanging lining when pressure is applied.

These operations appear complicated at first sight, but I believe that in practice they will not be more so than those that they replace.

Actually, the changing of a Thomas bottom requires from three to four hours. The joint between the bottom section and the bottom is made either by throwing in balls of dolomite by hand through the nose of the converter, which requires great skill, or by pouring in, by means of buckets, dolomite mixed with an excess of tar, so that the paste shall be sufficiently liquid to run down into the joint. This is dried and the vessel heated up. By this method you have a vertical joint which must stand a good deal of work, and, on account of its necessary repairs, is often a cause of delay.

By the other method, the bottom and lower part are built up in one place, and the vertical joint is done away with. There is, in truth, a horizontal joint, but it is very easy to make, and, besides, does not wear out. As to the delay, it would be about one and one-half hours, and if it is not necessary to heat up the bottom and the vessel, it can be brought down to about forty-five minutes. In practice, in order to replace the bottom section and bottom, the delay is at least from 8 to 10 hours for a ten-ton converter ; for a bottom, a lower section and a certain distance above, it is about 18 hours. By the new process, it appears, it would not be more than about two hours. As to the curve and the nose, the duration of the stoppage is very variable. It depends altogether upon the greater or less difficulty that there is in breaking away the mass of hard slag. This repair is often made at the same time as that of the bottom section ; let us suppose that it

takes six hours more. If the skull is very large, it is hardly probable that this method of operating would be practicable unless we give to this part of the converter, as well as to the others, a form of construction which will allow rotation when they are separated.

I give below a table of delays which actually occur in the replacing and maintenance of the lining of a ten-ton converter, supposing the apparatus to remain in place in the casting house.

1 new bottom and new lining, ...	24 hours.
2 bottoms replaced while the vessel is hot, . .	7 "
1 bottom and bottom section put on a cold vessel, .	10 "
2 bottoms replaced while vessel is hot, . .	7 "
1 bottom, one bottom section and one lower section,	18 "
2 bottoms replaced while vessel is hot, . . .	7 "
For a belly and a nose when replacing a bottom section,	6 "
9 bottoms.	79 hours.

Suppose that each bottom lasts from 18 to 22 heats; take a mean of 20 heats with 40 minutes per heat, which is rather slow work. The effective life of a lining would be 120 hours for 180 heats of ten tons each. The delays would amount to 66 per cent. of the working time. It should be noted that the life of a converter is not always that given above as a type. By the other method the probable delays would be as given in the following table:

1 bottom with a vessel entirely relined, . . .	8 hours.
5 bottoms with bottom sections replaced while vessel is hot, ...	8 "
1 bottom, bottom section and lower section, . .	2 "
2 bottoms and bottom sections replaced while vessel is hot, ...	3 "
For belly and nose while replacing the bottom section,	3 "
9 bottoms.	24 hours.

Under the same conditions as before, stoppages would not be more than 20 per cent. of the working time. There is a good chance that each bottom would make a greater number of heats, since, owing to the absence of the vertical joint, the bottom and

bottom section form a true monolith, in place of being in three sections. It is evident that the bottom would resist better under this latter condition, besides there would be no stoppages required for repairing the joint.

I retrace my steps in order to speak of the selection and preparation of the dolomite. Certain dolomites are friable; they should be rejected because they will cause great loss. Others during the burning cinter and agglomerate into a mass enclosing unburnt dolomite. It is necessary then to let the cupola go out and break up this mass. This is especially true of dolomites containing iron, hence they are not suitable. In the early days, dolomite was calcined in reverbratory furnaces of which the bottom was made of dolomite and had flues for draft. Setting aside the enormous expense for fuel and the irregularity of the calcination, one was very lucky if not compelled to tear the furnace down to get the material out, the lining of which formed a veritable monolith with the dolomite. Later dolomite was calcined in a cupola lined with a rammed basic mass. This succeeded so well that the same method is generally employed today.

There are two methods of calcining dolomite in a cupola. The one, continuous, consists in charging alternately in the cupola in thin layers, dolomite and coke. This is economical as far as fuel is concerned, but it is impossible to obtain all the dolomite properly calcined owing to the irregular descent in the cupola occasioned by the drawing out of the calcined dolomite, It requires, besides, very careful workmen on the cupola and above all for the operations which are to be afterwards carried out, as, for example, to select the properly burnt dolomite, which must be sieved in order to clear it of the dust, and then inspected piece by piece. In selecting the properly calcined dolomite, they are guided by the appearance, the weight, and, in case of doubt, by the fracture. The other method is intermittent. When the cupola is completely filled, it is lit and when the fire reaches the top, it is allowed to burn out. When cold, the dolomite is drawn out. Much of this dolomite is strongly cintered together because an excess of coke is used in this method in order to be certain that all the dolomite is calcined (this point is exceeded somewhat). It is also necessary to have cupolas of larger diameter than in the first process in

order to prevent scaffolds. This later method requires more coke, but it entirely does away with the delicate operation of drawing, always an uncertain one, requiring much care.

The calcined dolomite is broken up, then crushed, and finally mixed with tar. It must not be exposed to the air any more than is possible, and above all not to damp air. These precautions are absolutely necessary after it has been mixed with the tar. Therefore you can not carry much of a stock, which is troublesome since the complete relining of a converter takes from 25 to 40 metric tons. I ought to observe that when vessels are lined in the casting house, the dolomite is exposed to the steam made in watering the ingot moulds and slag. This is repeated at each heat and can not help but be objectionable. It can be avoided by employing the means indicated before, consisting of assembling in the casting house the different sections of the converter. Let us now consider what the composition of the pig iron should be.

SILICON.

The content of silicon varies according to local circumstances from 0.2 per cent to 1 per cent., and even passes this last limit. However, it is preferable for it not to reach 1 per cent., for then one wears out the lining of the converter, especially chemically. The silicon by its combustion develops a large amount of heat which remains in the bath and which, under these conditions, is sufficient to cause the combination of a part of the silica formed with the magnesia of the lining, the quantity of lime which has been melted, doubtless, being not sufficient to absorb the silica. If the iron contains less than 0.7 per cent. of silicon, in order to work with cupola melting, it is necessary to have, first, coke of the best quality in order to obtain metal physically very hot; since silicon, being the element which is burnt out first, will not be able to furnish by its own combustion, owing to its small amount, a sufficient quantity of heat to give the bath the desired fluidity. The iron is then thick, the blast does not work well in the bath, since there is a tendency to travel through the metal in jets just as it enters the tuyere holes.

Second: An increased amount of manganese is desirable; it should exceed 2 per cent. when the silicon is 0.4 per cent; first in order to render the iron more fluid, otherwise there will be violent

eruptions during the period of decarburization, and above all that this element may, by its combustion, develop sufficient heat so that the lime will commence to melt by the time the after blow begins, otherwise dephosphorization will go on slowly and there may be danger of having a cold heat which could not be cast and would be full of blow holes. It should be noted that the contents of Silicon, Manganese and Carbon decrease when pig iron is remelted in a cupola.

For direct working the iron should have a little less silicon. It will then blow very well as it will be very warm, physically, when the blast furnace is working normally.

SULPHUR.

The content of sulphur is of importance on account of the cracks which it may cause during forging. At about 0.10 per cent. of sulphur, steels show a tendency to crack, and consequently, when using the indirect method, the pig iron may contain as much as 0.10 per cent of sulphur, since it is possible to desulphurize the metal during the melting in the cupola by using a coke free from sulphur; it is necessary besides that the iron should be very manganiferous. There is likewise a slight decrease of sulphur during the blowing in a basic converter.

When using direct metal, it is necessary to keep the sulphur below 0.10 per cent. Such iron is not difficult to make in a blast furnace, since the Thomas iron produced today varies from a trace up to .07 per cent. of sulphur. The allowable limit in the steel depends altogether on the use to which it is to be put. For machinery, sheet and shovel steel, that is to say for the steels which will have a good deal of work put on them, it is necessary to pay particular attention to the sulphur content. With pig iron containing .06 per cent. of sulphur, there will, however, be no danger. There is in use today a process for desulphurizing iron in the liquid state, while in the presence of manganese. This consists in holding the bath of iron, of from 70 to 100 metric tons, in a machine built somewhat like a converter of large volume. Employed primarily as a mixer, it was noticed that the iron remaining in this apparatus was desulphurized. The plant being once erected, the expense for maintenance and labor does not exceed 10 centimes (two cents) per ton of iron, when the quantity treated

is 100,000 metric tons per year. With this apparatus, the advantages of remelting disappear entirely since you can obtain an iron perfectly regular and containing as little sulphur as the cupola could furnish.

PHOSPHORUS.

The content of phosphorus can vary from 1.8 per cent to about 2.4 per cent., according to whether the blast furnace works with or without the addition of puddle cinder to the burden. The Ilsede pig iron has 2.9 per cent. of phosphorus. This amount is unnecessary.

With 1.8 per cent. of phosphorus, it is necessary to have 1 per cent. of silicon. This will give a very strongly mottled iron, grey perhaps, and manganiferous; say from 1.75 per cent. to 2 per cent. of manganese, otherwise there is danger of having steel so cold that you would be unable to cast it. The best iron for the indirect method should contain about 2.3 per cent. of phosphorous, 0.7 per cent. silicon, and 1.6 per cent. manganese. For the direct method you will get along equally as well with a little less silicon, say 0.1 per cent. to 0.2 per cent. less. If you exceed 2.3 per cent. of phosphorus, you will blow too hot and will not dephosphorize well without chilling off by adding scrap or by increasing the amount of lime; and in order to produce steel of a good quality, it will be necessary to increase the percentage of manganese in the pig iron.

MANGANESE.

The content of manganese should not be less than 1.2 per cent. This should be increased if you wish to make steel of extra quality and especially so for extra soft steels, which on delivery will be subjected to the most severe cold bending tests. For in that case it is necessary to make a regular steel and one containing relatively little manganese which it is difficult to do with steels made with ferro-manganese.

CARBON.

The content of carbon should be that of a mottled to grey pig, almost graphitic, if you are aiming to make extra soft steel, equal to that produced in the Open Hearth furnace. The presence of graphitic carbon in the pig iron, as well in the acid Bessemer as in the basic Bessemer, tends to improve the quality of the steel. Graphitic irons blow very well since they are very fluid, and are

much less severe on the lining of the converter. Is it not possible to attribute the superior quality of the steels made from graphitic irons to the following circumstances?—The bath being very fluid, the air is extremely well divided up, hence more of the oxygen being so thoroughly disseminated through the mass, meets those elements with which it combines before attacking the iron, the latter being protected by the excess of dissolved carbon.

Passing now from this examination of the metal that can be made, let us indicate briefly its different uses.

Extra soft dephosphorized steel gives as results of tension tests, from 25 per cent. to 29 per cent. elongation with ultimate strengths varying respectively from 48 to 45 kilos.

A square bar having a section of 40 mm. (1 9-16 inches), after having been plunged at a cherry red heat into cold water, can be bent around at an angle of 180 degrees without any sign of crack or flaw. In order to obtain these results, the steel must contain very little manganese, 0.35 per cent. as a maximum.

This steel welds perfectly. The manufacture of spades is a striking example. For this purpose, the steel should not be dephosphorized too much. The composition should be somewhat as follows: Carbon .12 per cent.; phosphorous, .11 per cent.; manganese, .60 per cent. and higher. The manufacture of carriage and wagon tires is also another example of the welding powers of extra soft Thomas metal. Steels not quite so soft would weld equally as well. Since 1885 soft steel has been used in France to partly replace merchant iron. The statistics for 1890 show for this country a production of 696,583 tons of merchant iron, and 284,484 tons of merchant steel.

Iron shafting and machinery is no longer manufactured except in Belgium, and in a part of the French Ardennes. The French navy was already using this metal in 1885 in the manufacture of its machinery. The manufacture of plates of this steel is carried on to a large extent and the manufacture of rails from Thomas steel is, so to speak, a matter of ancient history.

We now come to the manufacture of beams from soft steel, which justly occupies the attention of all metallurgists and particularly of the Belgians. The situation can be shown more clearly by comparing the cost of Thomas ingots in Belgium, in

Luxemburg and in Longwy, that is to say, in some of the principal producing centers which are in a position to export their products. In order to get at this cost price, I will suppose that the plant consists of three ten-ton converters using the direct process; that the production in 12 hours is 150 tons, which means a heat every forty-two minutes. The number of working days per year will be 300, and the ingots obtained will therefore be 90,000 tons.

LABOR FOR TWENTY-FOUR HOURS.
(DOUBLE TURN.)

UNLOADING STOCK:	FRANCS.	DOLLARS.
Coal: 45,000 kilo (99,000 lbs.) at one franc (20 cents) each 10 tons (22,000 lbs.) .	4.50	.90
Lime: 54,000 kilo (118,800 lbs.) at franc 1.60 (32 cents) each 10 tons, .	8.64	1.73
Dolomite: 16,500 kilo (36,300 lbs.) at franc 1.25 (25 cents) each 10 tons, . .	2.06	.41
Coke: 13,000 kilo (28,600 lbs.) at franc 1.50 (30 cents) each 10 tons, . .	1.95	.39
Sundries, ...	5.00	1.00
Total, ...	22.15	4.43
One-half of this should be charged to each twelve-hour turn, ...	11.08	2.22

	FRANCE.					CHARLEROI.				
NAME OF POSITION.	No. of Men.	RATE PER MAN.		COST OF 300 TONS.		No. of Men.	RATE PER MAN.		COST OF 300 TONS.	
		fr.	$	fr.	$		fr.	$	fr.	$
Engineer	1	10	2.00	10	2.00		7	1.40	7	1.40
Ass't Engineers	4	5	1.00	20	4.00		4	.80	16	3.50
				COST OF 150 TONS.		1 4			COST OF 150 TONS.	
One-half of above	....	......	......	15	3.00	....	......	......	11.5	2.30
Firemen	2	4	.80	8	1.60	2	3.50	.70	7.00	1.40
Water Tenders	1	4	.80	4	.80	1	3.50	.70	3.50	.70
Ashwheelers	2	3.25	.65	6.50	1.30	2	3.25	.65	6.50	1.30
Spiegel Cupola Melter and Charger	1	5	1.00	5.00	1.00	1	4.50	.90	4.50	.90
Helper	1	3.25	.65	3.25	.65	1	3.00	.60	3.00	.60
Engineer	....	......	......	......	......	....	......	......	......	......
Pig Iron Ladle	1	4.50	.90	4.50	.90	1	4.00	.80	4.00	.80
Weighmaster	1	3.75	.75	3.75	.75	1	3.50	.70	3.50	.70
1st Vesselman	1	6.00	1.20	6.00	1.20	1	4.50	.90	4.50	.90
2d Vesselman	1	5.00	1.00	5.00	1.00	1	3.80	.76	3.80	.76
Runner or Trough-men	2	3.75	.75	7.50	1.50	2	3.50	.70	7.00	1.40
Ladleman 1st	1	5.75	1.15	5.75	1.15	1	5.00	1.00	5.00	1.00
" 2d	1	5.00	1.00	5.00	1.00	1	4.25	.85	4.25	.85
" 3d	1	4.75	.95	4.75	.95	1	4.00	.80	4.00	.80

Name of Position.	France. No. of Men.	France. Rate per Man. fr.	France. Rate per Man. $	France. Cost of 150 Tons. fr.	France. Cost of 150 Tons. $	Charleroi. No. of Men.	Charleroi. Rate per Man. fr.	Charleroi. Rate per Man. $	Charleroi. Cost of 150 Tons. fr.	Charleroi. Cost of 150 Tons. $
Pitman 1st	1	6.50	1.30	6.50	1.30	1	5.50	1.10	5.50	1.10
" 2d	1	5.50	1.10	5.50	1.10	1	4.75	.95	4.75	.95
" 3d	1	5.25	1.05	5.25	1.05	1	4.25	.85	4.25	.85
" 4th	1	5.00	1.00	5.00	1.00	1	4.00	.80	4.00	.80
" 5th	1	4.75	.95	4.75	.95	1	4.00	.80	4.00	.80
Ingot Handlers	4	4.25	.85	7.00	3.40	4	4.00	.80	16.00	3.20
Weigher and Marker	1	4.50	.90	4.50	.90	1	4.25	.85	4.25	.85
Hyd. Valves-men	1	5.00	1.00	5.00	1.00	1	4.50	.90	4.50	.00
" " "	1	4.75	.95	4.75	.95	1	3.75	.75	3.75	.75
" " boys	2	2.00	.40	4.00	.80	2	2.00	.40	4.00	.80
Blowing Engineer	1	5.00	1.00	5.00	1.00	1	4.50	.90	4.50	.90
Helper-boy	1	2.50	.50	2.50	.50	1	2.25	.45	2.25	.45
" "	1	2.20	.44	2.20	.44	1	2.00	.40	2.00	.40
Engineer Pressure	1	4.25	.85	4.25	.85	1	3.50	.70	3.50	.70
" Blowers	1	4.00	.80	4.00	.80	1	3.00	.60	3.00	.60
Cinder man	1	4.00	.80	4.00	.80	1	3.50	.70	3.50	.70
Clean-up under vessels	4	4.00	.80	6.00	3.20	4	3.60	.72	14.40	2.88
Oiler for Cranes	1	3.25	.65	3.25	.65	1	3.00	.60	3.00	.60
Lime Charger	1	4.50	.95	4.50	.90	1	4.00	.80	4.00	.80
Messenger for the two Foremen	1	2.00	.40	2.00	.40	1	1.75	.35	1.75	.35
Test-smith	1	5.00	1.00	5.00	1.00	1	4.25	.85	4.25	.85
Helper	1	2.00	.40	2.00	.40	1	1.75	.35	1.75	.35
Tool-smith	1	4.50	.90	4.50	.90	1	3.80	.76	3.80	.76
Striker	1	3.25	.65	3.25	.65	1	3.00	.60	3.00	.60
Refractories Foreman	1	8.00	1.60	8.00	1.60	1	6.00	1.20	6.00	1.20
Dolomite Cupola, 1st	1	4.75	.95	4.75	.95	1	3.75	.75	3.75	.75
" 2d	1	4.50	.90	4.50	.90	1	3.25	.65	3.25	.65
" 3d	2	3.50	.70	7.00	1.40	2	3.00	.60	6.00	1.20
Engineer Dolomite Grinding Mill	1	4.00	.80	4.00	.80	1	3.00	.60	3.00	.60
Helpers	3	3.75	.75	1.25	2.25	3	3.00	.60	9.00	1.80
Bottom man, 1st	1	6.00	1.20	6.00	1.20	1	4.50	.90	4.50	.90
" " 2d	1	5.00	1.00	5.00	1.00	1	4.00	.80	4.00	.80
" " 3d	3	3.50	.70	10.50	2.10	3	3.00	.60	9.00	1.80
Heater—Fireman	1	2.00	.40	2.00	.40	1	2.00	.40	2.00	.40
Dolomite Brickmaker	1	5.00	1.00	5.00	1.00	1	4.00	.80	4.00	.80
" " 2d	1	4.50	.90	4.50	.90	1	3.50	.70	3.50	.70
" " 3d	1	3.50	.70	3.50	.70	1	3.00	.60	3.00	.60
" " 4th	1	3.25	.65	3.25	.65	1	3.00	.60	3.00	.60
Stopper-maker	1	5.00	1.00	5.00	1.00	1	4.00	.80	4.00	.80
Boss Mason	1	8.00	1.60	8.00	1.60	1	6.00	1.20	6.00	1.20
Mason	4	5.00	1.00	5.00	1.00	1	4.50	.90	4.50	.90
"	......	......	......	......	......	1	4.25	.85	4.25	.85
"	......	......	......	......	......	2	4.00	.80	4.00	.80
Helpers	2	3.50	.70	7.00	1.40	2	3.00	.60	6.00	1.20
"	4	3.25	.65	13.00	2.60	4	2.75	.55	11.00	2.20
Foreman Repair Gang	1	5.00	1.00	5.00	1.00	1	4.00	.80	4.00	.80
Helpers	4	3.25	.65	13.00	2.60	4	3.25	.65	13.00	2.60
Unloading Stock	......	......	......	11.08	2.22	......	......	......	11.08	2.22

At Dudelingen they recarburize by means of briquettes of anthracite, and similar trials in England and Westphalia have given excellent results. The disappearance of the Spiegel cupola in a short time may therefore be prophesied. In this particular there will be an economy; and besides the steel thus obtained is of a superior quality to that produced when employing spiegel as a recarburizer as this always causes a little of the phosphorous to pass back into the steel.

COST OF CONVERSION (FROM MOLTEN IRON TO INGOTS) AND COST OF INGOTS PER TON.

PER TON OF STEEL.	CHARLEROI.		LIEGE.		DUDELINGEN.		LONGWY.	
	fr.	$	fr.	$	fr.	$	fr.	$
Iron: 100 to 200 kilo. Loss (220 to 440 lbs.) 16% to 20%, at 57.75 fr. ($11.55) per ton........	11.55	2.31	55.46 fr. per ton. 11.09	2.32	48.50 fr. per ton. 9.70	1.94	52 fr. per ton. 10.40	2.08
Coal: 150 to 165 kilo (330 to 363 lbs.) at 12.50 fr. per ton ($2.50)	2.07	.414	2.07	.414	18.03 fr. per ton. 2.98	.596	17.55 fr. per ton. 2.90	.58
Coke: 40 to 45 kilo (88 to 99 lbs.) at 20 fr. per ton ($4.00)..........	.90	.18	18.75 fr. per ton. .85	.17	24.03 fr. per ton. 1.09	.218	23.55 fr. per ton. 1.06	.212
Dolomite: 55 to 60 kilo (88 to 99 lbs.) at 20 fr. ($4.00) per ton...	.30	.06	....	....	.30	.06	6 fr. per ton. .36	.072
Lime: 180 to 190 kilo (396 to 418 lbs.) 18 to 19% at 8 fr. per T ($1.60)......................	1.62	.324	8 fr. per ton.	....	11 fr. per ton. 2.09	.418	2.09	.418
Tar: 5 to 6 kilo (11 to 13 lbs.) about 1 gallon at 7 fr. ($1.40)..	0.42	.084	....	....	....	....	....	....
Fire Brick, Sand, etc................	0.85	.17	....	....	....	....	....	....
Moulds and Stools....................	0.95	.19	....	....	....	....	....	....
Black Lead Stoppers..................	0.35	.07	....	....	....	....	....	....
Sundries..............................	1.40	.28	....	....	....	....	....	....
Railroad Expenses (Shifting).......	.10	.02	....	....	8.66	1.73	28.66	1.732
Salaries..............................	2.09	.418	....	....	plus	....	plus	....
General Expenses.....................	0.50	.10	....	....	....	....	0.14	.028
Amortissment.........................	0.50	.10	....	....	0.30	.06	0.35	.07
Recarburizers: 5 to 6 kilo (11 to 13 lbs.) ferro-manganese 0.5 to .6%, 250 fr. per ton.............	25.50	.30	....	....	....	....	0.10 0.05	.02 .01
	25.10	5.01	....	....	25.12	5.02	6.11	5.22
Less Value of Slag..................	3.00	.60	....	....	3.00	.60	3.00	.60
Cost of Conversion...................	22.10	4.41	....	....	22.12	4.42	23.11	4.62
Add Cost of Iron.....................	57.75	11.55	about	....	48.50	9.70	52.00	10.40
Cost per Ton of Ingots.............	79.85	15.96	77.85	15.57	70.62	14.12	75.11	.... 15.02

It is possible to still further reduce the labor cost by working the "refractory" plant on day turn only. It would then be necessary to increase the number of men, but the chiefs, the first and second hands, would be replaced by ordinary laborers.

COST OF CONVERSION (FROM MOLTEN METAL TO INGOTS) AND COST OF INGOTS PER TON.

The coal and coke being taken at the current price (March, 1892), 8 francs ($7.60), for the coal on cars at the mines, and 14 francs ($2.80) for the coke on cars at Bracquegnies and Tilleur.

PER TON OF STEEL.	CHARLEROI.		LIEGE.		DUDELINGEN.		LONGWY.	
	fr.	$	fr.	$	fr.	$	fr.	$
Iron: Loss 100 to 200 kilo (220 to 440 lbs.) 16 to 20% at 52.55 francs per ton ($10.51)................	10.51	2.10	50.26 fr. per ton. 10.05	2.01	43.30 fr. per ton. 8.66	1.732	46.60 fr. per ton. 9.32	1.864
Coal: 150 to 165 kilo (330 to 363 lbs.) at 8.50 fr. per ton ($1.70)............	1.40	.28	1.40	.28	14.035 fr. per ton. 2.32	.464	13.55 fr. per ton. 2.24	.448
Coke: 40 to 45 kilo (88 to 99 lbs.) at 16 francs per ton ($3.20)...........	0.72	.14	14.75 fr. per ton. .67	.134	20.035 fr. per ton. .90	.18	19.55 fr. per ton. .88	.176
Dolomite: 55 to 60 kilo (121 to 132 lbs.) at 5 francs per ton ($1.00)....	.30	.06	....	....	0.30	.06	6.00 fr. per ton. 0.36	.072
Lime: 180 to 190 kilo (396 to 418 lbs.) 18 to 19% at 8 fr. per ton ($1.60)..	1.62	.324	8.00	....	11 fr. per ton. 2.09	.418	2.09	.418
Tar: 5 to 6 kilo about 1 gallon at 7 francs........	0.42	.084	....	....	....	....	....	....
Fire Brick, Sand, etc.......	0.85	.17	....	....	....	....	....	....
Moulds and Stools...........	0.95	.19	....	....	....	....	....	....
Black Lead Stoppers........	0.35	.07	....	....	....	....	....	....
Railroad Expenses, Sh'p'g	0.10	.02	....	....	....	....	....	....
Sundries.......................	1.40	.28	....	....	....	....	....	....
Salaries.......................	2.09	.418	....	....	8.66	1.732	8.66	1.732
General Expenses...........	0.50	.10	....	....	plus	....	plus	
Amortissment.................	0.50	.10	....	....	....	....	0.14	.028
Recarburizers, ferro-man-							0.35	.07
ganesse, 0.5 to 0.6 %							0.10	0.02
2.50 francs per ton	1.50	.30	....	....	0.30	.06	0.05	.01
	23.21	4.642	....	....	23.23	4.646	24.19	4.838
Less value of slag..........	3.00	.60	....	....	3.00	.06	3.00	.60
Cost of Conversion.........	20.21	4.042	....	....	20.23	4.04	21.19	4.238
Add Cost of Iron...........	52.55	10.51	about	....	43.30	8.66	46.60	9.32
Cost per ton of Ingots......	72.76	14.552	69.92	13.98	63.53	12.706	67.79	13.558

The cost price, which will vary one or two francs (20 to 40 cents) between the different works, depending on such local details as may arise, is based on an annual production of 90,000 of ingots. This quantity could be increased to 140,000 tons by making a heat every half hour, if the two-thirds were used up in the manufacture of beams. This increase in the production would require only a few extra workmen, viz.: two firemen, one water tender, one test-smith, four men on refractories, and one mason, in all nine men for an increase of 55 per cent.

The prices for the coal and coke were those current in the summer of 1890. The calculated cost of the pig iron at Charleroi, is based on coke costing 18 francs ($3.60) on cars at Bracquegnies; for Duffelingen and Longwy, 18 francs on cars at Tilleur.

The coke delivered at the three works would therefore cost respectively, 20 francs, ($4.00); 24.03 francs ($4.81), and 23.55 francs ($4.71). The figures that I have taken for Dudelingen and Longwy are certainly the maximum one for this time, since both works have several sources of supply that they could put in operation, which in many circumstances would permit them to obtain lower prices the Belgian coke workers offer to the native works.

90,000 tons of ingots require 108,000 tons of pig iron which will represent the production,

First—Of five blast furnaces using cinder on their burden, and presuming that they each have a daily output of 65 tons and work 350 days in the year. Sixty-five tons per day is an enormous production as the use of cinder requires very slow working in order to obtain regularly an iron of the proper quality.

Second—Not quite the entire output of four blast furnaces using the brown hematites of Luxemburg and making 90 tons per day. For Longwy more than four blast furnaces will be required, since the ores are very silicious. The iron made on Sunday must be remelted in the cupola, and the cost will be slightly increased by this fact. It would perhaps be as well to look into the matter and see if it would not be preferable to stop the blast furnace over Sunday: if you can maintain the quality of pig iron in starting on Monday, there will be an advantage

in so doing according to information received from very reliable sources.

The average price of rolling steel with Gjers pits and reversing engines would be about 13 francs ($2.60) a ton for the works at Charleroi and Liege, when the weight of the smallest mill bars is not less than 15 to 20 kilos to the running metre (say 30 to 40 pounds per yard). The finished beams would cost then 92.50 to 93.50 francs ($18.50 to $18.70) a ton, or a thousand kilos at Charleroi, 80.50 to 90.50 francs ($16.10 to $18.10 a ton) at Liege, as long as puddle cinder can be obtained in sufficient quantities, or on the discovery and use of an ore cheaper than the one used today, and with which slags need not be used. By increasing the cost of rolling two francs (40 cents), the cost of the beams for Dudelingen and for Longwy would be respectively 85.50 to 89.50 francs the thousand kilo ($17.10 to $17.90 per ton), according to the market price of coal and coke. In March, 1892, the price per ton of beams was respectively, at Charleroi, 85.50 to 86.50 francs ($17.10 to $17.30 per ton), at Liege, 82.50 to 83.50 francs ($16.50 to $16.70 per ton); at Dudelingen, 78.50 ($15.70); at Longwy, 82.50 to 83.50 francs ($16.50 to $16.70 per ton).

The production of puddle cinder implies the manufacture of puddle iron. Now, I think, that one can say that this will disappear little by little. It is very difficult to decide on this struggle for existence and on the customs of buyers.

As to price, can it not be said *a priori* that the advantage will always be on the side of steel, if the following points are taken into consideration? In order to produce from pig iron a metal susceptible of being rolled or forged, it is necessary first to maintain it in a liquid state so that the chemical actions may take place, consequently it must be furnished with heat; secondly, to mix the materials that are being transformed in order to establish the contact between the chemical elements which are to produce the reaction, and so to obtain the result; thirdly, to use a refining agent.

The first is very costly in the puddling furnace; it is free in the converter. The second is produced in the puddling furnace, with very few exceptions, by manual labor on small quantities, whilst in the converter very large quantities are acted upon by

the aid of very powerful engines, the steam expense of which can be still more decreased by employing triple expansion engines which will be possible by using the boiler of Prosper-Hanrez. The third costs a little in the puddling furnace, whilst it is free in the converter. The loss in finished product will be greater when using the puddling furnace than when using the converter, and it is almost impossible to hope to reach, by means of the puddling furnace, the quality obtained by the converter. The difference in value of the two finished products will then more than make up the difference in price between the two sorts of pig iron.

SHALL THE COLLEGE GRADUATE ENTER THE UNITED STATES CIVIL SERVICE?

As the student nears the close of his course, the idea of entering the Civil Service is sure to be presented to him in some form or other, and so at this time a few words on the subject may not be out of place.

There is a sentimental attraction about the City of Washington that makes it dear to the heart of every true American, for it is the scene of action of legislative forces which affect the entire country, and there is a fascination in the very thought of living in the place where the men whose words and deeds fill our newspapers walk about like ordinary mortals. It is a favorite place for excursions and gatherings of all kinds, and thus most of us have already visited it. If so, its wide, clean, shady streets and magnificent public buildings; its social, easy-going population and mild climate, make an impression not easily forgotten.

The Government employs at Washington, in various capacities, between twenty and thirty thousand people drawn from every State and Territory in the Union. In the departmental service, with which we are chiefly concerned, the hours are from nine to four, with half an hour for lunch. One month vacation, and one month sick leave are allowed per year with full pay. A furlough without pay may usually be had by special application, and pay during a period of sickness of several months is sometimes allowed. The work itself is mainly of a routine nature which

soon becomes rather dull, and from which, as a rule, very little knowledge of value can be acquired. In the interest of the Government it is necessary that this should be so, for a man who has spent, say five years, examining stove-lifters or adding columns of figures, will accomplish much more if left where he is than if transferred to another department. The pay, in nearly all branches of the service, is good for the work done, being usually from 50 to 100 per cent. better than that received for similar work in business offices.

These considerations draw crowds of office seekers to Washington each year, and, according to the motive impelling them, they may be divided into three classes.

First, those who come merely because the pay is better and more certain than they can get elsewhere.

Second, those who could do better outside, but are attracted by the short hours and rather lazy life.

Third, those who take office as an easy means of livelihood while they are pursuing some special branch of study.

The collegiate, sad to say, is to be found among the first and second class, as well as among the third. Most of the positions which attract the graduate (with the exception of the higher political ones) are in the classified Civil Service, and are filled by means of a competitive examination, open to every American citizen.

While a large number of collegiates occupy clerk and copyist positions, which in themselves require only a common school education, we will confine ourselves to the consideration of places with stricter requirements, and where more or less of the knowledge gained in a University course is brought into play.

The chief positions of this kind are: Assistant Examiner, Patent Office; Topographical Aid or draftsman, Geological Survey; Architectural Draftsman, Office of the Supervising Architect of the Treasury; Mechanical Draftsman, Patent Office; and Computer in either Geological or Coast Survey or Naval Observatory. Between three and four hundred examinations are held each year; of these about one-fourth are held in Washington, and the rest scattered throughout the States as the number of applicants from any locality make advisable. Application

blanks and information regarding examinations can be obtained from the Secretary of the Civil Service Commission. The examinations are very impartial, and the papers are marked without the examiner knowing to whom they belong, so that to this point there is no "influence" that can be of any value. However, after the examination is passed and the persons name placed on the eligible list, he may be appointed to fill any vacancy that occurs, even though there are many others waiting who outranked him in the examination. In the clerk and copyist positions, where the number on the eligible list runs up into the thousands, there is very little chance of obtaining a position without influence to secure the appointment, but in the high-grade positions, which we are considering, the proportion of the applicants to vacancies is much smaller, and persons are very frequently appointed without any influence whatever. In fact, special examinations are occasionally held to fill positions for which there are no eligibles. Let us now take up the above mentioned positions more in detail.

The position of Fourth Assistant Examiner in the Patent Office offers, perhaps, more inducements in the way of opening up a career than any of the others. The career in prospect is that of a patent lawyer. As soon as appointed, the Examiner is assigned to some suitable division, if he is a Civil Engineer, perhaps to the Department of Bridges or some similar work, if a Mechanical Engineer or Electrical Engineer, he is given work that would come under those heads as far as possible. He receives the drawings and models of the article for which a patent is wanted and goes over them carefully, first to see if it is a *useful* invention and therefore patentable, and then to see if it infringes on something already patented. It usually will infringe in some detail or other; the Examiner then rejects the application, stating his reasons therefor, and a new application must be made out. The wording of these applications is an important matter, and for this purpose a Patent Attorney is usually employed by the inventor. The training and knowledge of patent law which the Examiner gets in the course of his work, fits him almost in itself for the position of patent lawyer. Most of the Examiners enter the service with a future of that sort in view, and supplement their work by

attending evening lectures on law, which are always to be had in the Winter in Washington. However, an Examiner is not allowed to practice patent law for two years after leaving the Government service; and this fact often proves a serious barrier to advancement, especially if the intending lawyer has lived up to the full extent of his income, as it is the general tendency of the Government employe to do. The Fourth Assistant Examiner receives a salary of $1200 per year, and has a chance of promotion successively to the positions of Third, Second, and First Assistant, and, finally, to that of Chief Examiner. The increase in salary is $200 per year with each promotion up to the position of First Assistant. The Chief Examiner receives $2500 per year. Whenever it is made necessary by vacancies, examinations for promotion are held, and positions are usually given to those standing highest in the examination. If the assistant works reasonably hard and passes good examinations, he will, perhaps, be promoted, on an average, once in two years until he becomes First Assistant on a salary of $1800 per year. The position of Chief Examiner is still open to him, but the probable time of getting it is rather indefinite. This is the highest position that he can reach by means of examinations.

The applicant for the position of Fourth Assistant is examined in the following subjects which are made of equal weight in the marking:

1. Physics.
2. Technics.
3. Mathematics and Chemistry.
4. Mechanical Drawings.

The requirements in Physics are not more than those found in the Engineering Course here. The examination in Technics requires a general knowledge of a large number of subjects, from the manufacture of common articles, like rubber and sugar, to methods of steam propulsion and the action of the phonograph. The Mathematics do not exceed the entrance requirements at Lehigh, and the Chemistry not more than that taught in the first term Freshman. For the fourth subject some Patent Office drawings are supplied, and the applicant is required to state the views given, the principles involved, and the use of the machine.

In the three years, ending June 30, 1891, there were 69

persons who passed the examination for the position of Fourth Assistant, and of these 44 were appointed.

With this exception the positions under consideration do not in themselves lead to any good independent way of gaining a living, and unless the applicant intends to spend his life in the Government service, they are mainly useful in allowing plenty of time for study in other directions.

The applicant for the position of Topographic aid in the Geological Survey is examined in the following subjects, which are all given equal weight in the marking with the exception of the first, which only counts half as much as any of the others.

1. Letter Writing.
2. Algebra.
3. Geometry.
4. Plane Trigonometry.
5. Surveying.
6. Geodesy.
7. Astronomy.
8. Topographic Drawing.

The examination would be extremely easy to anyone well up in the corresponding subjects in the Civil Engineering Course. The one securing the position will get general field work, and for perhaps a year may learn enough new things of value in after life, to pay him for the time spent. The salary is $720 per year. In the two years ending June 30, 1891, there were 26 persons who passed the examination, and four who were appointed.

The examination for the position of Topographic Draftsman is in the following subjects, which are given in the marking the relative weights set opposite them.

	WEIGHT.		WEIGHT.
1. Letterwriting,	1	4. Tracing,	5
2. Geography,	2	5. Scale Drawing,	5
3. Arithmetic,	2	6. Contour Construction and Lettering,	5

The requirements in the first three subjects are no more than those for admission here. In the last three the time consumed is taken into account, as well as accuracy and finish of the work. The whole examination is limited to nine consecutive hours. The work of the Draftsman is mainly in enlarging or reducing the original field sheets, and affords little chance for improvement, save in that special direction. If the appointee is assigned to the

Interior Department he will receive $900 per year, with a fair chance of rising to $1200 in a year or so. If assigned to the War Department he may receive $1000 or $1200 at the start. In the three years ending June 30, 1891, there were 25 who passed this examination, and 12 who received appointments.

The applicants for the position of Architectural Draftsman are examined as follows:

	WEIGHT.		WEIGHT.
1. Letter Writing,	1	3. Construction,	4
2. Designing,	5		

In Designing, a plan view of a building is given the applicant and he is required to design a suitable elevation, giving details of the stone work, etc. In Construction he is required to compute the stresses, graphically, in a roof truss, and to design a somewhat complicated column to support the varying strains from the roof to the foundation. This examination is held only when the needs of the service require it. The salary is $3.00 per day, with reasonable chanee of promotion to $6.00. In the three years ending June 30, 1891, there were 35 who passed this examination and six who were appointed.

The Mechanical Draftman's examination is in the following subjects:

	WEIGHT.		WEIGHT.
1. Letter Writing,	1	4. Shading and Shade, and Section Lines,	6
2. Arithmetic,	2		
3. Tracing,	5	5. Mechanical Drafting,	6

In the last subject the applicant is given a sketch and description of some piece of mechanism, such as a new harvester, and is required to make a scale drawing of the same in conformity with the rules governing such drawings in the Patent Office. Most of those securing this position are assigned to the Patent Office, and are employed in making drawings of inventions for the use of inventors and others. The salary is $1000 per year. In the three years ending June 30, 1891, there were 21 who passed this examination and five who were appointed.

The subjects for the Computers' examination are

	Weight.		Weight.
1. Orthography,	1	5. Algebra,	4
2. Penmanship,	1	6. Geometry,	4
3. Copying,	1	7. Logarithms,	4
4. Letter Writing,	1	8. Trigonometry,	4

The questions are all very easy as compared with those asked in college examinations. If the applicant wishes to try for a position in the Naval Observatory, he is asked some additional questions in Astronomy. They are no more, however, than are contained in our course in Astronomy, first term Senior. If the applicant is assigned to the Treasury he receives $4.00 per day, if to either of the other departments from $900 to $1000 per year. If in the Coast or Geologic Survey, he has a chance of eventually receiving between $2500 and $3500 per year. In the three years ending June 30, 1891, there were 45 who passed this examination of whom 17 received appointments.

In the following tables, compiled from the Civil Service records, the foregoing figures and some additional information is collected. Under the head of non-collegiate are comprised all those who have not had a University education, or are not graduates of a college other than a business college. The appointments in all cases are those made from the corresponding number who passed.

Some of the above positions afford very good compensation for the service rendered, and all of them allow plenty of time for self-improvement. Most of the graduates who take such positions have this in view, with the intention of eventually striking out for themselves, but few of them ever voluntarily leave the service. This fact is brought about by the following causes:

First. It is not often that a position is offered to the employe which will immediately pay him as well as the one he already has. He can not afford to work for less than he has been receiving, for while in office he has lived up to the full extent of his income, if not a little beyond it; he has no money saved up, and has lost the faculty of economizing. The certainty of his pay, while in office, acts against his saving, and, then, living in Washington is expensive; not that it necessarily costs more to

live there than anywhere else, but the inducements to spend money are greater.

FOR THE YEAR ENDING JUNE 30th, 1889.	Number examined.	PASSED. Education. Non-Collegiate.	PASSED. Education. Collegiate.	PASSED. Total.	FAILED. Education. Non-Collegiate.	FAILED. Education. Collegiate.	FAILED. Total.	Per cent. of Collegiates who passed.	Total number appointed.	Per cent. of those who passed who were appointed.	SALARY PER YEAR.
POSITION.											
Assistant Examiner, . .	50	3	19	22	11	17	28	53	13	60	$1200
Topographical Draftsman,	16	4	5	9	6	1	7	83	4	44	900
Architectural Draftsman,	27	11	2	13	8	6	14	20	1	08	3.00 per day
Mechanical Draftsman, .	5	0	1	1	4	0	4	100	1	100	1000
Computer, ...	34	1	13	14	4	16	20	45	7	50	900 to 1200
June 30, '89—June 30, '90.											
Assistant Examiner, . .	44	7	13	20	10	14	24	48	16	80	$1200
Topographic Aid, . . .	39	0	19	18	8	13	21	58	4	22	720
Topographical Draftsman,	24	4	9	13	3	8	11	53	3	23	900
Mechanical Draftsman, .	6	2	3	5	1	0	1	100	1	20	1000
Computer, ...	3	2	0	2	0	1	1	00	2	100	1000 to 1200
June 30, '90—June 30, '91.											
Assistant Examiner, . .	79	9	18	27	19	33	52	35	15	55	$1200
Topographic Aid, . . .	27	0	8	8	8	11	19	42	0	00	720
Topographical Draftsman,	9	2	1	3	5	1	6	50	3	100	900 to 1200
Architectural Draftsman,	61	20	2	22	33	6	39	25	5	23	3.00 per day
Mechanical Draftsman, .	48	10	5	15	19	14	33	26	3	20	1000
Computer.	45	7	22	29	6	10	16	69	6	21	1000 to 1200

Second. If he has been long in office, the short hours and easy requirements are liable to enervate him and make him unfit to meet the sterner demands of business life.

Third. The almost absolute security of his position, and the

certainty of his pay, make him hesitate to trust himself to the uncertain chances of an independent business.

For these reasons, in answer to the general question, "Shall the college graduate enter the Civil Service?" I would say, "no."

E. C. REYNOLDS, '93.

SOCIETIES.

THE ENGINEERING SOCIETY PRIZE OFFER.

The Engineering Society, at the meeting held April 27, decided to offer prizes for treatises, which may be written during the coming Summer and Autumn. Some of the more important rules governing the contest are here given in part.

1. The treatises may deal with any subject, such that the discussion will be suitable in nature for publication in the engineering periodicals.

2. The length shall be between 1200 and 3500 words. They shall be accompanied by drawing or photographs when necessary.

3. The prizes shall be ten dollars, five dollars, one year's subscription to THE QUARTERLY, and honorable mention.

5. The committee of judges shall be Mr. J. S. Siebert, Mr. H. H. Stoek, and Mr. G. E. Wendle.

7. Saturday, October 14, 1893, shall be the latest date upon which papers may be submitted in competition.

8. The announcement of the award shall take place at the annual supper of the Society.

The complete rules (giving the qualities considered in awarding prizes, manner of submiting papers, etc.) have been posted in Packer Hall.

At the same meeting Mr. Siebert read an interesting paper on "The Origin of Weights and Measures," with special reference to the metric system. Mr. Warman read a paper on "The Measurement of Rainfall and Precipitation at Bethlehem." Mr. Frost, chairman of the Mechanical Engineering Committee, gave a review of the recent mechanical achievements.

The last meeting for the year was held May 25. President

McKenzie read a report of work done the past year. The report of Treasurer Peck showed the Society to be on a sound financial basis.

The following officers were elected to serve the coming year: President W. H. Kavanaugh; Vice-President J. V. Martenis; Secretary, W. A. Payne; Treasurer, J. L. Burley.

The Society is in a flourishing condition. It is the intention to hold meetings oftener during the coming year, and, if possible, arrangements will be made to have addresses given by prominent alumni.

ELECTRICAL ENGINEERING SOCIETY.

A meeting was held in the Physical Laboratory, April 19. The first paper was read by Mr. Parkhurst, '93, on "Electric Welding." In this he described the several methods of welding in use at the present time, mentioning many interesting points that are involved in this newly developed art. Mr. Trout, '94, then read a paper on the "Edison Pearl Street Station in New York," which was of special interest to the Juniors.

The next meeting was held May 17, in the Physical Laboratory, with the President in the chair. No papers were read, as the meeting was given up entirely to business. It was decided not to take into membership all the Electrical of the coming Junior Class, as has been the custom, but to admit only those who show sufficient interest in the Society to warrant their membership. It is hoped this new move will not reduce the number of active members materially, and that it will at least insure more enthusiasm as a body than is now manifest.

The officers elected from the Junior Class for the following year are: President, E. A. Grissinger; Vice-President, F. G. Sykes; Secretary, J. L. Neufeld; Treasurer, E. O. Warner.

A committee was then formed to draw up a constitution for the Society, the former one having been misplaced.

EDITORIAL.

WE announce the Board of Editors for 1893–94 as follows: Barry H. Jones, *Chairman;* James L. Burley, *Secretary;* Elwood Grissinger, William S. Maharg, William V. Pettit, Jr., Edwin G. Rust; Fletcher D. Hallock, James E. Brooks, *Business Managers.*

OUR readers will note the omission of the Index of Articles from technical periodicals. Lack of space, and the fact that to give the index a degree of completeness, which would make it really valuable, would require considerable more space than has been given to it in some of our issues, are the chief reasons for laying it aside. There is also, among the editors, a feeling of doubt as to whether the index is sufficiently used to justify the work put upon it. The question of its continuance next year is now under advisement, and we would be glad to receive from our readers expressions of their opinion on this point. Communications on this or any other subject, should be addressed to The Editor, Bethlehem.

WE do not deem it expedient, in this number, to indulge in our usual review of the work of our contributors; the articles can all speak for themselves, and need no special recommendation. We would like to call attention to the fact that this issue has more reading matter, by twenty per cent., than any other QUARTERLY yet gotten out, the space usually occupied by the index being filled in this manner. We desire to express to our contributors for the year our gratitude for the excellent articles which they have given us, and for their assistance in making the magazine what it is; for we believe it not too much to claim that the QUARTERLY is entitled to call itself a first-class technical college periodical.

WE would bespeak for our successors a much more liberal financial support, in the way of subscriptions, than has been received in the past. The present year was entered upon

with a good sized debt; we have brought matters out square for the year, by some hard work, but the debt still remains. This must be removed if the QUARTERLY is to be a successful and permanent institution, and we hope that the men in college will rally to its support at the beginning of next year. Especially do we commend to the new Alumni the duty of showing their interest in their *Alma Mater* by keeping up a connection with her active life through this journal. The editors aim to publish what is of practical value as well as scientific interest, and are especially glad to put on record the results of the experience and research of our Alumni.

FOR LEHIGH MEN.

This column will contain, chiefly, such information in regard to addresses and occupations of Alumni as does not appear in the latest issue of the *Lehigh Register*. Please contribute.

'78. H. C. Wilson, C.E., U. S. Engineer Office, Galveston, Tex.
'79. R. H. Tucker, Jr., C.E., Lick Observatory, Mt. Hamilton, Cal.
'83. G. F. Duck, E.M., Fairmount, W. Va.
'87. E. P. Van Kirk, B.M., 722 S. 17th St., Philadelphia, Pa.
'88. Edmund Bates, C.E., Bellefonte, Pa.
'88. D. L. Mott, C.E., Houlton, Me.
'88. W. L. Wilson, C.E., care J. I. Miller, West Brownsville, Pa.
'89. F. J. Carman, A.C., 1351 Q St., Washington, D. C.
'89. J. S. Kellogg, Jr., A.C., Illinois Steel Co., South Chicago, Ill.
'89. A. L. Rogers, M.E., 542 Jefferson St., Milwaukee, Wis.
'89. J. B. Wright, C.E., 425 W. 22d St., New York City.
'90. F. R. Fisher, C.E., 1845 N. 22d St., Philadelphia, Pa.
'91. Warden Cresson, M.E., Hazleton, Pa.
'91. J. R. Davis, C.E., Port Jervis, N. Y.
'91. Walton Forstall, E.E., 440 Dearborn Ave., Chicago, Ill.
'91. H. M. Knapp, C.E., Hamilton Bridge Works, Hamilton, Ontario, Can.
'92. W. Y. Brady, C.E., 2203 Carson St., S.S., Pittsburg, Pa.
'92. Thanlow Gjertsen, C.E., 101 Highland St., Cumberland, Md.
'92. C. K. Shelby, M.E., 1604 Summer St., Philadelphia, Pa.
'86. J. S. Siebert, C.E., Box 53, Allentown, Pa.

The Secretary of the Alumni Association, Mr. H. H. Stoek, South Bethlehem, would like to know the addresses of the following Alumni:

'73. J. P. S. Lawrance,
'88. G. R. Baldwin,
'88. G. P. Dravo,
'89. H. W. Harley,
'89. J. J. Martin,
'89. S. E. Lambert,
'90. C. E. Fink,
'90. C. H. Detweiler,
'91. J. E. Boatrite,
'91. H. D. Stilson.

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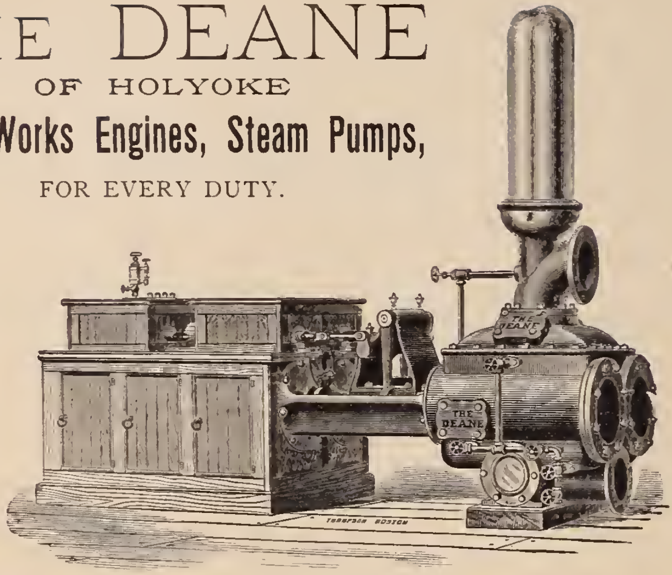

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